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STATE OF MONTANA

Supplemental Information

for the

Environmental Protection Agency

on

DEPREDATION OF LIVESTOCK

and

USE OF 1080

SINGLE LETHAL BAITS

and

MONTANA'S EXPERIENCE WITH M-44

1977 TO PRESENT

STATE DOCUMENTS COLLECTION

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MONTANA DEPARTMENTS
of
Agriculture
Fish, Wildlife and Parks
Health and Environmental Sciences
Livestock

August 6, 1981

The State of Montana presents the following supplemental information in response to the requests from the EPA panel members at the hearing on 1080 held in Denver, Colorado on July 28, 1981. The panel requested information on the economics of livestock losses from predators in Montana, the use of 1080 single lethal baits and Montana's experience with M-44 sodium cyanide devices.

In the limited time made available to submit additional information, the State of Montana has compiled and prepared the following information. Panel members or EPA personnel requiring an expansion or clarification of this information should contact Dr. James Glosses, Administrator of the Animal Health Division, Montana Department of Livestock, Agriculture Livestock Building, Capitol Station, Helena, MT 59620, telephone 406/449-2043. Dr. Glosser will coordinate all requests with the other three state departments.

Economics

The increase or decrease in livestock numbers, particularly sheep, is a normal event in Montana. The dramatic loss of sheep numbers in the 1970's resulted from two primary factors: 1) market economics, and 2) depredation. The number of sheep was declining in the late 1960's. This decline was exacerbated by market economics and predator problems. The decline in sheep numbers is now stabilizing primarily because of improved markets. We would expect a decline to result once again if market prices are depressed because of the inability of some producers to achieve control of depredating coyotes. Producers may withstand some increase in depredation problems when markets are favorable.

Montana can provide an historical perspective of sheep or other livestock numbers to EPA. In our opinion, such a perspective is not necessary or required by FIFRA. What difference does it make if livestock numbers are increasing or decreasing in the state? The important point is that individual livestock producers are experiencing significant depredation. When EPA registrations are granted for other pesticides, such as one to protect grain crops, the question of grain production fluctuation is not required by EPA to achieve registration. Why is such a standard being required for 1080 and not other pesticides?

Should EPA require population trends, then only the experience of individual producers should be considered. State, regional or national population figures do not reflect the type, volume, or characteristics of individual producer operations and their problems.

The relevance of question number 1 as set forth in the Federal Register to the depredation of livestock or use of a control tool such as 1080 is questionable. Should a requirement be imposed on use of 1080 for urban rat control that requires that the human population in these areas or available food supplies must have fluctuated a given percentage prior to registration or use of 1080. NO! The relevance of increasing or decreas-

ing populations or production volumes for the use of other control tools is also questionable. Does the agency require a registrant to prove that existing herbicides are adequate to protect a crop prior to approval of another herbicide? NO!

We recognize that the RPAR process does allow for an economic benefits review and a risk assessment of a pesticide. However, 1080 as a predacide is not within the RPAR process.

Loss of Livestock from Depredation

The severity of livestock losses, based upon state, regional, or national projections provides information on the trends of livestock depredation. For example, historically the average loss of livestock from coyotes ranges from 4 to 8% in any given year in Montana. Lets say a state has a sheep population of 100,000 and experiences a 5% loss from coyote depredation in a given year. If there were 1000 producers then conceivably each producer on the average would have a loss of 5 sheep. Obviously such a loss by the 1000 producers individually is insignificant.

We all know that pest problems, including depredation by coyotes, is not equally shared by each producer. Some producers experience severe losses while others experience insignificant losses. Once we begin to include in the analysis of depredation loss such factors as size of the operation, its location (mountains, hills, prairie), range versus farm flock, vegetation differences and other factors, then the use of averages becomes meaningless in determining the significance of depredation.

We do not believe that averages or range of losses is proper in evaluating, approving or disapproving any pesticide, including 1080. The actual experience of individual producers that are verifiable is the only acceptable parameter for developing a management program to reduce depredation. We have attached as Appendix I information from various producers in Montana. These producers raise livestock in different regions of the state, have different flock sizes and continue to experience varying depredation losses.

Using verified loss data from the Department of Interior and loss figures of individual producers, we believe depredation of livestock in Montana is proven. We know Montana producers are using the best available management techniques and control tools to protect their livestock and to reduce predation. We recognize that some producers are not experiencing significant predation problems while other producers are. We believe this dictates that any control programs must address individual producer problems. Pest management programs must address the actual producer problem. A producer experiencing pest problems is not transferable to another producer operation within 1/4 mile or 200 miles away; except in a general programmatic sense.

Coyote Populations

The question concerning the current coyote population in Montana does not directly relate to increase or decrease in livestock population.

Producers experience high depredation of livestock in areas of low coyote population and vice versa. Availability of natural food sources for coyotes, such as voles, mice, and rabbits, impact depredation of livestock more than coyote populations. The same situation is true for antelope or deer. (See Appendix II)

The attached Job Progress Reports are from the Montana Department of Fish, Wildlife and Parks reporting the results of studies conducted to determine the effects of coyote predation on big game populations in the Missouri Breaks of central Montana.

The attached Memorandum, dated July 14, 1981, is a brief summary of some of the results of the above studies, plus some information on a follow-up study. The final report of the follow-up work is being prepared and will be completed this fall. When this document is available, a copy will be forwarded to EPA for their perusal.

If one would base the decision on the use of a control tool such as 1080 on coyote populations, then the trigger for implementing control is coyote population levels, whether or not depredation is or is not occurring. We recognize ideally that all control tools should be used to control the offending animal. Realistically we accept the fact that limited local population may be necessary to control coyotes in the vicinity of an individual livestock operation to reduce predation.

We summarize our position on livestock numbers, loss of livestock from predators and coyote population as follows:

We accept that statewide, regional, or national figures on the three items are useful to generally assess the overall problem. However, their use to develop, evaluate or implement a control program or to allow the use of a specific control tool is limited.

The use of individual producer operations, management systems, and experiences with depredation is the most acceptable mechanism to assess the need for predator control. Once the need is verified then a management scheme utilizing applicable production techniques and controls can be implemented. The controls utilized may or may not include the use of 1080. We do not believe EPA should make a decision of 1080 or any other pesticide based upon general economic data or the size of coyote population. The decision should be based upon individual producer's production systems, their economic situation and their actual depredation experience, whether or not coyote populations are high or low.

New Information on Baits

We had obtained some information indicating that British Columbia was employing a baiting technique that greatly lessened the impacts to non-target species. We contacted the Williams Lake Conservation Office and obtained this information. It is included as Appendix III.

The Montana Department of Livestock licenses state, commercial and private applicators. The Department has received numerous complaints from the applicators in recent years. The major complaints are: devices are not effective when they are frozen in the ground; too many restrictions and paperwork, faulty design in the mechanism, caking of the capsules, and individuals using the devices who were not experienced trappers were generally not successful.

The following information reflects Montana's experience with the use of the M-44's.

A. U. S. Fish & Wildlife Applicators

Year (Calendar)	Number of Applicators	Number of Coyotes Harvested
1977	21	221
1978	23	130
1979	25	107
1980	22	96
1981[1]	21	77

1 - through June 1981.

B. State Licensed Governmental and Commerical Applicators.[1]

Year (Calendar)	Number of Applicators	Number of Coyotes Harvested
1977	88	285
1978	65	109
1979	50	45
1980	40	25
1981[2]	99	14

1 - licensed annually.
2 - through June, 1981.

Private applicators are licensed for 5 years. In 1977, 176 applicators were licensed. In 1978, 112 applicators were licensed. From 1979 to present, no applications for licensing were processed. The number of coyotes harvested are unknown.

Conclusions

We request that this additional information be incorporated with the oral and written testimony previously provided to EPA. We believe that a program of controlled and judicious use of 1080 for predator control can be justified and is warranted in Montana. Such a program should be developed with the premise that the individual producer's predation problems are the key in determining whether or not control methods should be implemented. The goal would be to remove the depredating

coyote(s) from the local population. We are convinced that this can be accomplished with the use of 1080 single lethal dose baits.

- END -

DOCUMENTED SHEEP LOSSES DUE TO COYOTE DEPREDATION - MONTANA

A. Plains region

1. Name: Ed Smith Address: Dagmar County: Sheridan

Telephone: (406) 483-5484

Topography - plains, eastern Montana.

Type of Operation: farm flock, 500 ewes, in small fenced pastures. This operation was in existence in the 1940's. 1080 bait stations were first used in 1947 and continued up until 1972. The owner contends the stations were very effective.

1) Losses before 1972 (1947-1972) - lambs only, losses ranged from 1 to 2 percent.

2) Losses after 1972:

Year	Losses (Percent)
1973	10
1974	20
1975	22

In 1975, the owner sold his sheep since he could not contend with losses any longer. During the period 1973-75, the sheep were checked several times daily and the culprit coyotes were shot. In the last year, the majority of deaths occurred after the first check of the band in the morning during the breakfast hours.

2. Name: Michael G. Devlin Address: Terry County: Prairie

Telephone: (406) 486-5533

Topography - plains, eastern Montana.

Type of Operation: bands grazing in large fenced pastures. This ranch started raising sheep in 1966. From 1966 to 1972, 1080 bait stations were in use at the rate of one station per township. Sheep numbers, 1800 ewes. Losses relate to lambs only.

1) Losses before 1972 (1966-1972) negligible - 0.1 to 1.0 percent.

2) Losses after 1972:

Year	Losses (Percent)
1973	1
1974	5
1975	6
1976	13
1977[1]	11
1978[2]	3
1979	5
1980	10

1 - Owner purchased fixed winged aircraft for the purpose of aerial hunting. Area flown was the owner's property only.

2 - Montana aerial hunting permits were initiated. The owner secured permission to hunt an 8 mile perimeter surrounding his ranch.

The owner alleges the resurgence of predation in 1980 to be the result of an open winter with no snow cover which hampered the effectiveness of spotting coyotes. The winter of 1981 was also open and the effectiveness of aerial hunting was again impeded. To date, the 1981 lamb losses subsequent to docking is 5% with the next two months of heavy predation experience still to come.

3. Name: Lawrence Capra Address: Boyes County: Carter

Telephone: (406) 427-5372

Topography - plains in southeastern Montana.

Type of Operation: bands grazing in fenced pastures. This operation was started in 1955 and comprised 1000 ewes. 1080 bait stations were in constant use since 1948. Also, Carter County has employed a fixed wing pilot to conduct aerial hunting on a fulltime basis and a fulltime trapper since 1946. At present, the county assesses each sheep producer 80 cents per head to conduct predator control.

1) Losses prior to 1972: 1/2 to 1 percent (lambs).

2) Losses after 1972:

Year	Losses (Percent) Lambs
1973	2
1974	2
1975	3
1976	5
1977	10
1978	8
1979	5
1980	5

4. Name: John Ryan Address: Jordan County: Garfield

Telephone: (406) 557-6181

Topography - plains, eastern Montana.

Type of Operation: bands grazing in large fenced pastures. This operation was in existence since the 1940's. 1080 bait stations were used constantly since 1947 or 1948. Herding was practiced on this ranch.

1) Losses before 1972 - lambs only
1947-1968 less than 1/2 percent.
1968-1972 2 percent.

2) Loss after 1972: lambs only.

Year	Losses (Percent)
1973	3
1974	30 (270/900)
1975	30
1976	30
1977	not available
1978	" "
1979	" "
1980	40 (234/580)

In 1973, approximately 900 ewes were maintained, the numbers reduced yearly to a low of 580 ewes in 1980 when the owner sold out his sheep operation.

5. Name: Fred Itcaina Address: Malta County: Phillips

Telephone: (406) 673-3167

Topography - plains to foothills, north central Montana.

Type of Operation: several bands (1000+ head) are grazed in large open tracts. Herders are with the bands constantly. The ranch is approximately one township (36 square miles) in size. Since 1948, 1080 bait stations were utilized where permitted; exceptions, Ft. Belknap Indian Reservation to the east and the Charles M. Russell Game Preserve to the south.

1) Losses prior to 1972: (ewes & lambs) minimal - 2 - 3 percent.

2) Losses after 1972 (ewes & lambs)

1973 - 1977	10 - 12 percent
1978	8
1979	7
1980	7

The owner attributes the decline of 12 percent in 1977 to 8 percent in 1978 to the increase in aerial hunting activity because of an increase in fur prices. Since 1973, the owner hired a fulltime trapper in addition to the federal trappers available in the area. In 1977, 1500 coyotes were harvested on this ranch. In 1972, 4 bands were maintained; this was reduced to 3 in 1975 when cattle operations were increased. In 1980, 2500 ewes were sold and replaced with cattle.

6. Name: Garth Tooke Address: Ekalaka County: Carter

Telephone: (406) 775-6455

Topography - plains in eastern Montana with rough breaks and coulees.

Type of Operation: bands grazing in fenced pastures. The present owner assumed management of the ranch from his father in 1969. 1080 bait stations were used during the period 1969-1972.

1) Losses before 1972 - lambs only.	1969	4/250	(1.6%)
	1970	87/587	(14.2%)
	1971	70/723	(9.7%)
	1972	45/694	(6.5%)
2) Losses after 1972 - lambs only.	1973	36/715	(5 %)
	1974	108/759	(14.2%)
	1975	99/559	(17.7%)
	1976	33/533	(6.2%)
	1977	113/570	(19.8%)
	1980	45/722	(6.2%)

In 1977, 30 ewes were also lost due to coyote predation. In addition, two 2 year old heifer cows were destroyed because of predation and 11 calves were killed in this same pasture. The high population density of coyotes is reflected by the fact that 69 coyotes were harvested during the period June 1 through August 15, 1977 in this five square mile pasture. Because of this, the sheep operation was curtailed. The owner went back into the sheep raising business in 1980 utilizing a different tract of land owned by him.

B. Foothills region

7. Name: Don McKamey Address: Cascade County: Cascade

Telephone: (406) 866-3320

Topography - rough foothills with area of dense brush and deep coulees.

Type of Operation: bands grazing in fenced pastures. 1080 bait stations were used since 1947. Herders were not used.

1) Losses before 1972 - minimal, less than 1/2 percent.

2) Losses after 1972 - lambs only.

Year	Loss (Percent)	Coyotes taken Total	Trapping	Shooting	Plane	Helicopter	Snares	M-44
1972	4	Unk	-	-	-	-	-	-
1973	9	68	Unk	Unk	Unk	Unk	Unk	Unk
1974	13	88	Unk	Unk	Unk	Unk	Unk	Unk
1975	13	140	62	15	15	32	1	15
1976	13	135	55	17	5	50	6	2
1977	9	95	49	10	6	16	15	0
1978	9	96	29	9	14	37	7	0
1979	7	87	21	6	29	26	5	0
1980	9	77	16	3	10	48	0	0

The owner contends that increased costs using the variety of control methods makes it difficult to stay in business.

8. Name: Cleon Graves Address: Roundup County: Mussellshell

Telephone: (406) 428-2389

Topography - foothills and plains in central Montana.

Type of Operation: bands grazing in large fenced pastures with herding practiced. 1080 bait stations were used from 1960 through 1972.

1) Losses prior to 1972: (lambs) losses were nil, less than 1/4 percent.

2) Losses after 1972: range from 10.4 percent in 1973 to 31.2 percent in 1980.

In 1980, the owner states that he lost in excess of $30,000 due to lamb deaths due to predation.

C. Mountain region

9. Name: John Baucus Address: Helena County: Lewis & Clark

Telephone: (406) 442-8829

Topography - rough foothills and mountainous terrain in western Montana.

Type of Operation: grazing bands in fenced pastures in the spring, open range (mountainous) in the summer, wintered on meadows.

Bands are herded in spring, summer and fall. 1080 bait stations were first used in 1950 and continued up to the ban (1972).

1) Losses in 1948-1949 - lambs only - 5%.

2) Losses prior to 1972: 2.5 to 3 percent. 22 year average is 2.67%.

3) Losses after 1972: lambs only

Year	Losses (Percent)
1973	4.0
1974	3.43
1975	6.1
1976	5.12
1977	5.71
1978	5.0
1979	5.1
1980	5.0

In 1969, this operation ran 12,000 ewes. That year some of the sheep numbers were sold; at present, the ranch runs 7,000 ewes.

10. Name: Vern Keller Address: Fishtail County: Stillwater

Telephone: (406) 328-8622

Topography - mountainous in south central Montana.

Type of Operation: bands grazing in the mountains in the summer, fenced pasture in the winter. This is a second generation sheep ranch. 1080 bait stations had been used since the late 40's up to the time of the ban.

1) Losses before 1972, ranged from 1/2 - 1%, lambs only.

2) Losses after 1972, ranged from 3 to 5 percent per year.

The owner believes that his losses have been contained to the stated range due to the practice of maintaining herders, an ongoing trapping program and intensive aerial hunting effort.

11. Name: Paul Hansen Address: Grant County: Beaverhead

Telephone: (406) 681-2264

Topography - mountains, western Montana.

Type of Operation: bands grazing in mountains in the summer, fenced pastures in the winter. This particular ranch has been in operation for over thirty years, however, this is the third generation engaged in sheep raising. 1080 bait stations were used constantly from the early fifties up until 1972.

1) Losses before 1972, never exceeded 1/2 percent.

2) Losses after 1972:

Year	Losses (Ewes & Lambs)
1973	1.5
1974	2
1975	5
1976	5
1977	6
1978	8
1979	7
1980	2

The owner states that his losses became significant in the third year of the 1080 ban and increased despite conventional methods of predator control, i.e. trapping, ground shooting. The decline in losses in 1980 are attributed to an increase in the number of hours of aerial hunting due to an increase in fur prices for coyote pelts.

APPENDIX II

JOB FINAL REPORT

RESEARCH PROJECT SEGMENT

STATE	Montana		
PROJECT	W-120-R-11 (5893)	TITLE	Statewide Wildlife Research
PROGRAM	III	TITLE	Non-game animal research
STUDY NO.	NG-47.1	TITLE	The effects of coyotes on big game populations in Montana
JOB NOS.	1 through 9	TITLE	Coyote densities, small mammal population indices, and big game fawn production and survival in the various study areas.

Period Covered: July 1, 1979 - June 30, 1980

Prepared by: Philip Schladweiler
Philip Schladweiler

Approved by: John P. Weigand
Eugene O. Allen

Date: Sept. 30, 1980

NOT FOR PUBLICATION - Results of this report may not be cited without the permission of the Director.

ABSTRACT

Data from all aspects of this study, conducted from 1975 through 1979 in 3 widely separated and ecologically divergent areas of Montana, are presented and discussed. Neither the scent post nor siren survey appeared suitable as a coyote census technique on all areas, although the siren survey apparently is the better where terrain doesn't limit hearing range. Coyote carcass collections provided a large volume of material for determination of food habits, sex and age structure, weights and reproductive performance, all of which are discussed in detail. Analysis of coyote scats provided additional food habits data. Coyote control accomplished the desired result of a minimum reduction of at least 50 percent of the precontrol population. Data on population levels of deer and antelope, as well as those of rabbits and rodents, are presented and discussed as they relate to population levels of, and predation by, coyotes. Coyotes can and do exert some short term control on deer and/or antelope populations in certain years and/or areas of Montana, but other factors ultimately control the long term population trends of these species. Under conditions existing during this study, it was concluded and recommended that coyote control is not justified and should not be carried out by this Department solely for the benefit of deer or antelope populations.

INTRODUCTION

Predator control is one of the most controversial issues in wildlife management today. This controversy has been further compounded (or confounded) by a general lack of factual data and by human emotion, which has tended to polarize opinions. At one extreme are advocates of total eradication of all large predators, while at the other are those who would prohibit any type of predator control for fear of upsetting the "balance of nature". However, as Henderson (1976) has pointed out, many people who profess interest in coyotes (*Canis latrans*) really have no understanding of the animal and most people who talk about controlling coyotes have no understanding of the implications and complications of "controlling coyotes".

Neither of the opposing viewpoints on predator control has prevailed and while simple predator control without regard for other ecological impacts is no longer generally acceptable, the concept of predator management is being increasingly discussed. Sound management, however, demands adequate knowledge of ecological relationships between predators and their habitat, including prey species. Impacts of various management options must also be understood. This is especially true of the coyote, whose great adaptability has allowed it to persist and even expand its range in the face of extreme persecution.

Since coyotes utilize a wide variety of prey, many people conclude that they necessarily have a negative impact on populations of these prey. This is especially true where game species may be the prey, and many sincere individuals view predators as the sole obstacle to almost unlimited abundance of game animals. The question of whether coyotes should be controlled for the benefit (real or imagined) of game populations frequently arises. It was raised with increased frequency, or at least more vociferously, following the presidential ban on the use of toxicants on federal lands, which went into effect in early 1972. As pointed out by Wagner (1975:7) increases in coyote populations were being reported immediately following the 1972 ban, and cause and effect was assumed. Wagner futher emphasizes that coyote population changes are more complex than simple responses to intensity of control and cites other studies showing that fluctuations (often quite pronounced) in coyote populations occur independent of predator control activities, apparently in response to fluctuating prey populations.

Coyote populations undoubtedly increased in some Montana localities following the 1972 ban, however, the clamor that something be done about the "coyote problem" seems to have been far out of proportion to actual changes in coyote populations. At about the same time a noticeable decline in deer numbers, especially mule deer (*Odocoileus hemionus*) but including white-tail deer (*O. virginianus*), occurred in many parts of Montana. These two phenomena were similarly interpreted by many as cause and effect. This concern for the effect of coyotes on game animals spawned the present study.

OBJECTIVES

To determine, within each of three vegetation types (shrub-grass prairie, mountain foothill, and river breaks) the:

Seasonal densities, movements and home ranges, and population dynamics of coyotes;

Relative population indices of various small mammal species as they relate to population levels of coyotes; and

Production and survival of deer and antelope fawns, and causes and timing of fawn mortality and relationships between these and population levels of coyotes and other coyote prey species.

Paired study areas were selected in each of the three vegetation types described above (see next section and Figure 1). All the data outlined above was collected from each area throughout the course of the study, and originally one of each pair was to be selected for intensive coyote control following approximately two years of baseline data gathering. The objective was to reduce coyote populations by at least 50 percent to see if this would have any effect on populations of prey species, especially deer, and to a lesser extent, antelope. Relatively light predation on deer in the Missouri Breaks areas, despite increasing coyote populations in 1978 and 1979 (see later discussion) led to postponing the coyote control phase in that area since reduced coyote populations could not have had much effect on already high deer survival prevailing at the time. The plan for Sixteenmile areas had to be modified when a misunderstanding with ranch personnel resulted in helicopter hunting over both study areas in November 1977. It was then decided to continue control on the entire area, and base comparisons on pre- and post-control data, and possibly compare these areas with portions of the adjacent Bridger Range where concurrent deer studies were being conducted.

STUDY AREAS

Study areas in the shrub-grass prairie type were located in the Miles City vicinity. One study area is located on a portion of Western Cattle Company's Hook Ranch, located in Rosebud County approximately 20 miles northewst of Miles City. The other is on the portion of the Fort Keogh Range Livestock Experiment Station (operated by the Agriculture Research Service of the USDA) lying south of the Yellowstone River and west of the Tongue River, and borders the southwest corner of Miles City. Figure 2 shows these areas in more detail. Both areas are primarily sagebrush-grassland types, and more detailed vegetational data for these areas appear in Appendix A.

River breaks study areas are located in the Missouri River Breaks on both sides of the Missouri River in northcentral Montana (Fig. 3). Collectively the two areas are referred to as the Missouri Breaks Areas. The Wilder Trail Study Area (also referred to as the South Missouri Breaks in some other reports) is located in northeastern Fergus County and extends from the Missouri River on the north to Crooked Creek on the south, and from Highway 191 on the west to the Skyline Trail (near the Fergus-Petroleum county line) on the east.

The Nichols Coulee Study Area (also called North Missouri Breaks) is located in southwestern Phillips County and runs from the Missouri River north to the Dry Fork Road, and from Highway 191 on the west to Coko Branch Road (CK Ridge) on the east. Vegetation, land ownership patterns and land use on the two areas are similar. Vegetation, topography, land use and wildlife are discussed in detail for the Wilder Trail and Nichols Coulee areas by Mackie (1970), and by Knowles (1975) and Komberec (1976), respectively. Additional data from the Missouri Breaks are included in the coyote population part of this study (Pyrah 1980) and in Hamlin (1979).

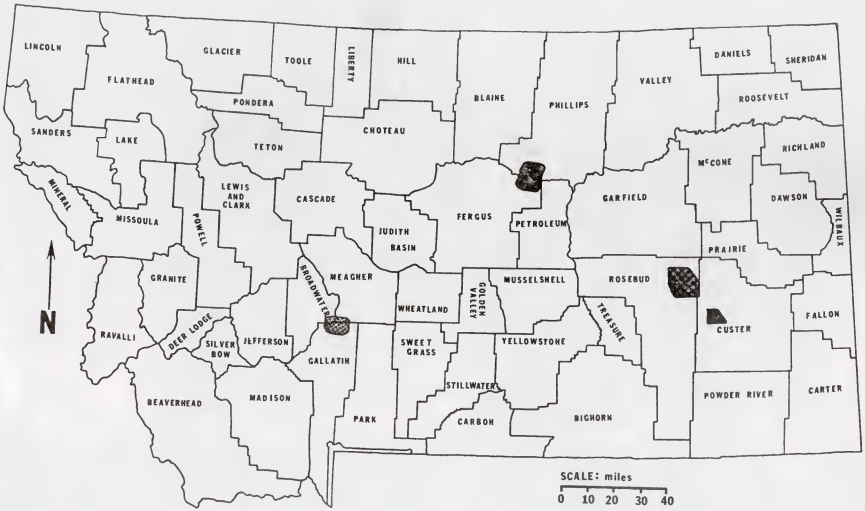

Figure 1. General locations of coyote-big game study areas within Montana.

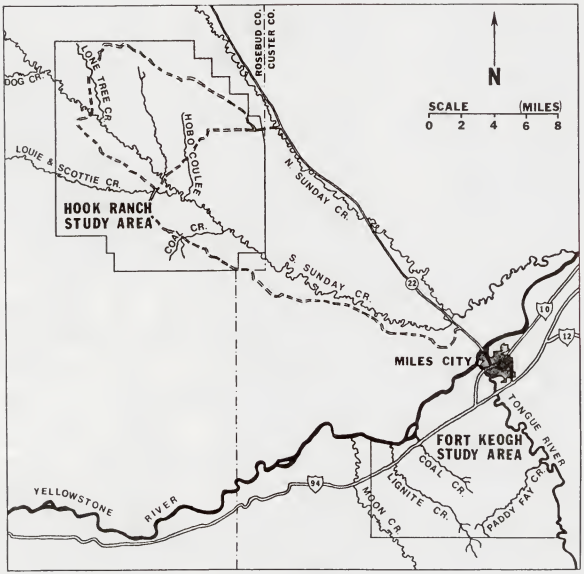

Figure 2. Location of shrub-grass prairie study areas near Miles City.

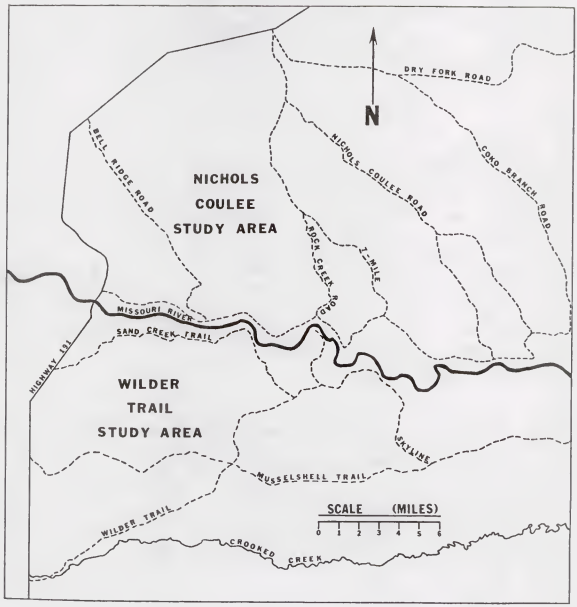

Figure 3. Location of river breaks study areas along the Missouri River in northcentral Montana.

Mountain foothill study areas were both located on the Climbing Arrow Ranch, located primarily in northeastern Gallatin County with small portions in southeastern Broadwater and southwestern Meagher Counties as well. These two study areas (collectively termed Sixteenmile Areas, Figure 4) are not separated by distance or a good physical barrier as are those in the Miles City or Missouri Breaks areas. The Haw Gulch Study Area encompasses approximately the western half of this area, while the Dry Canyon Study Area includes roughly the eastern half. Although no formal vegetational analysis was carried out, the Sixteenmile area can generally be characterized as extensive stands of shrubby and shrub-grass vegetation interspersed by open to moderately dense stands of Douglas fir (*Pseudotsuga menziesii*), limber pine (*Pinus flexilis*) and Rocky Mountain juniper (*Juniperus scopulorum*). At higher elevations timber stands are more extensive and dense, although large areas have been logged off in the past 25 years or so.

METHODS

COYOTES

Scent post surveys, developed by the U.S. Fish and Wildlife Service for their annual Survey of Relative Predator abundance in the Western United States (Linhart and Knowlton 1975), were conducted using materials and instructions supplied by the Fish and Wildlife Service. In addition to the annual fall survey, run in September of each year from 1975 through 1979, scent post lines were run in spring (mid-May to early June) and summer (mid-July to early August) of all years but 1979. Persistent snow drifts and poor road conditions delayed the first run on Sixteenmile Areas until late June in 1979, and the normal summer run was therefore deleted. A change was made in the attractant used for the fall 1976 and subsequent scent post surveys. According to results from field tests in several states (Roughton 1976) the new scent received 9 percent more visits than the previously used scent. Therefore, indices from previous surveys were corrected to allow comparison with fall, 1976 and subsequent surveys.

The siren survey technique is designed to provide an index to coyote population levels by stimulating them to howl in response to sounding a siren. Surveys were run on nights with little or no wind and usually began at least an hour after sunset. Each survey consisted of a series of stops (normally 10) at 3-mile (3.8 km) intervals, at each of which a siren was sounded for one full pitch cycle followed by a 1-minute listening period. This was immediately followed by another sounding of the siren and a 2-minute listening period. Since the objective of the survey was to obtain a response from as high a percentage of coyotes within our listening range as possible, the listening period was lengthened until all answering coyotes were identified or ceased howling. This sometimes exceeded five minutes. The number of individuals and groups of coyotes responding at each station, along with the direction and estimated distance, were recorded. When a group responded, an attempt was made to identify the number of individuals comprising the group.

Coyote carcasses were collected from hunters, trappers and fur buyers to obtain stomachs, female reproductive tracts and canine teeth.

Food habits were determined from analyses of scats and stomachs. Scats were collected from roads throughout the study areas as encountered. Each scat was

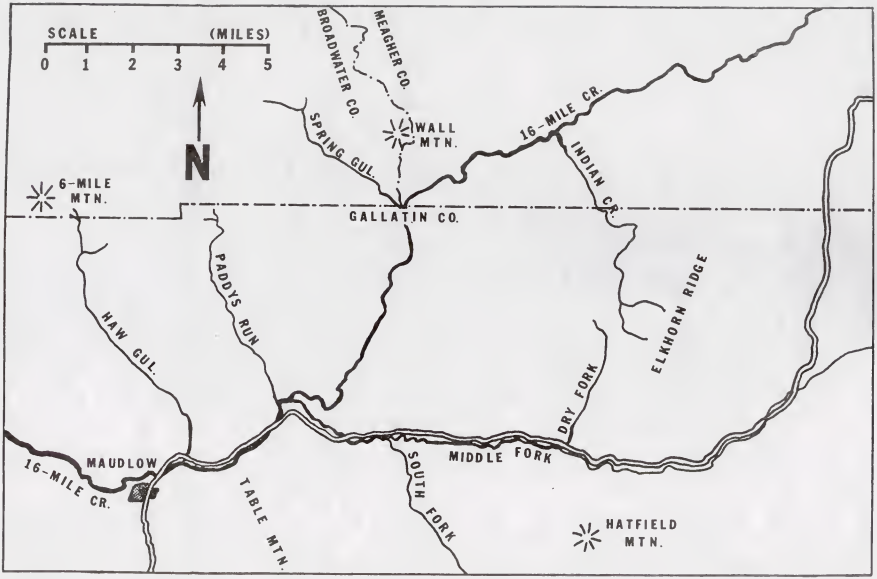

Figure 4. Location of mountain foothill study areas in southwestern Montana.

placed in a paper bag and labeled with location, date of collection and approximate date of deposition. Laboratory analysis consisted of soaking scats until they could be separated by washing, washing over a 20 mesh per inch screen, separation by flotation in a pan of water, identification of individual food items, and visual estimation (to the nearest one percent) of the volume each item comprised in each scat. Items representing less than one percent of a scat were recorded as a trace. Hair keys (Adorjan and Kolenosky 1969 and Moore et al. 1974) and reference collections of hair and skeletal materials were used to identify mammal remains. A seed reference collection and key (Martin and Barkley 1961) were used to identify wild fruits. Comparison of bird remains with study skins helped identify some of them, but bird remains in scats usually were too fragmentary to identify. Identification and analysis of food items in stomachs were completed as soon after collecting as possible, and was done in the same manner as for scats. Percent frequency of occurrence for each item, and the percent of total diet comprised by each item were computed by the aggregate percentage method of Martin et al. (1946).

Reproductive performance of coyotes was ascertained by counting placental scars in female reproductive tracts. Ovaries were sectioned and corpora lutea counted as a check on placental scar counts. Supplemental data on litter sizes was obtained from counts of pups at dens or intact family groups, prior to dispersal.

Coyote canines were sent to a commercial firm for sectioning and age determination by microscopic examination of cementum layers as described by Linhart and Knowlton (1967).

Coyote control included aerial hunting, which utilized both regular control efforts of both the Federal and State programs, as well as flights made specifically for this study on the Hook Ranch and Sixteenmile Areas. Additional aerial hunting was done by private individuals on these areas and probably on the Missouri Breaks Areas which lie outside the CM Russell Game Range. Trapping and/or hunting on the ground (including the use of snowmobiles) occurred on all study areas in at least some years and provided many of the carcasses collected. The M-44 device, a spring-loaded ejector mechanism which expells sodium cyanide crystals into the mouth of an animal which pulls on the baited end, were utilized in the spring of 1977 on the Hook Ranch area as a supplemental control technique.

BIG GAME

Data on distribution, population trends, and sex and age ratios of deer and pronghorn antelope (*Antilocapra americana*) were obtained from ground and aerial observations. Aerial observations included both fixed wing and helicopter flights. Fawn:doe and fawn:adult ratios and changes in these from late spring-early summer through the following winter were of special interest.

Mule deer fawns were captured on the Wilder Trail Study Area in June of 1976 through 1979. Captured fawns were marked with ear tags and either individually recognizable ear streamers or radio transmitter collars. Telemetry was used to study timing, extent and causes of neonatal fawn mortality. Capture and handling techniques, telemetry equipment and radio tracking procedures are as presented by Dood (1978), who also reports on criteria used to establish cause of death for any fawn carcasses located.

Efforts to document winter (December-March) coyote predation on deer (and later on antelope) were made on Missouri Breaks areas. Work was primarily limited to the bottomlands, river and reservoir ice, and the timbered breaks on either side of the river, especially on the Wilder Trail area. Periodic flights were made over the same sections of the river, its bottomlands and the upper parts of Ft. Peck Reservoir to look for carcasses. Four flights were made in winter 1975-76 and 8-10 in each subsequent winter. Roughly equal amounts of time were spent in on-the-ground field work each winter.

Seasonal changes in occurrence of deer or antelope in coyote scats provided information on timing of mortality in these species, although whether they were taken as carrion or actually killed by coyotes is frequently impossible to tell.

SMALL MAMMALS

Leporids - Roadside spotlight censuses were run on Miles City and Missouri Breaks study areas to survey cottontail rabbits (*Sylvilagus* spp.) and jackrabbits (*Lepus townsendii*), following the procedures outlined by Lord (1959). Spotlight surveys were on the same routes as siren surveys. Although both jackrabbits and cottontails occurred on Sixteenmile study areas, attempted spotlight surveys were unproductive, probably because of relatively low numbers (as verified by sightings at other times) at most times, and location of roads in relation to suitable habitat. Headlight counts also supplied the only data on populations of kangaroo rats (*Dipodomys ordii*).

A supplementary index to relative population levels of rabbits between areas or between years on a given area was obtained from pellet counts. Rabbit pellets were counted in 20 plots measuring 2x5 decimeters and spaced at 1.5 meter intervals along alternate sides of a 30.5 meter transect on Miles City areas. Fifteen transects, spaced at one mile (1.6 km) intervals along the length of scent post survey lines, were established and permanently marked on each area, so that the same plots were searched each year. Each plot, and a surrounding area approximately half the width of the plot, were cleared of pellets each year. Six additional transects were established on Ft. Keogh after poor road conditions necessitated moving part of the scent post line. In 1977, Trout (1978) conducted pellet counts in the Missouri Breaks but used a different method. These were not continued because of questionable results.

Rodents - Snap-trap lines were the primary method used to assess small mammal abundance on all study areas. Live trapping was used to supplement snap-trapping. Traplines were chosen to represent the major habitat types on each area. All snap and live trap lines on Miles City and Sixteenmile study areas consisted of 20 stations at 15 m intervals with 3 traps placed within a 1.5 m radius at each station. Traps were baited but not set for 2 nights, followed by 3 nights of trapping. Except for spring 1979 on Sixteenmile areas trapping was done in spring, summer and fall each year, with every live trap line being run each time. Individual snap-trap lines were run only once per year, always at the same season. A corresponding line in the same habitat type nearby was trapped the other seasons. Because of low small mammal populations and limited availability of live traps, only 2 traps per station were used on Miles City areas in 1977 and 1978. Trapping was done with Victor mouse traps (snap traps) and Sherman live traps (approximately 8x8x23 cm). A mixture of rolled oats and peanut butter was used for bait in all cases.

Missouri Breaks snap trap lines were similar to those on other areas except Victor rat traps were used exclusively and there were only 2 traps per station in all years. The single live trap line on the Nichols Coulee Study Area was identical to those on other areas in 1976, but only one trap per station was used thereafter. Live trapping on the Wilder Trail area was conducted by Trout (1978) in 1976 and 1977 on 2 grids (a 15x15 and a 10x18). Trap spacing was 15 m between rows and between traps within rows. He set traps in alternate rows each night and moved them to the adjacent row for the next night, and trapped for 6 or 8 nights. The same grids were trapped in 1978 and 1979, except that traps were set in each row each night. All animals caught on these grids were individually marked by toe clipping. Traps were not prebaited on Missouri Breaks areas.

Since deer mice (*Peromyscus maniculatus*) occurred on all areas and were the only species caught on many lines, an index of deer mice captures per 100 trap nights were calculated for each trap line. In addition, total captures (all species) per 100 trap nights were also calculated. Except for the Wilder Trail Study Area in May and June of 1976, when the student investigator did not keep records, traps sprung but with nothing in them were not considered as functional in calculating catch rates. Sprung traps were eliminated because the agents responsible (primarily cattle but including large insects, severe weather and probably other large animals) were primarily active during daylight hours, after traps were checked and set but before most small mammals were active. Catch rates for the live trap grids are expressed as total numbers of individuals captured.

RESULTS AND DISCUSSION

COYOTE STUDIES

Scent Post Surveys - Results of all scent post surveys are shown in Table 1. Linhart and Knowlton (1975) point out that there are many variables and problems associated with this technique. On nearly all of our study areas one or more coyotes were noted to have visited several adjacent stations on a given night. In several other cases, scats and/or tracks have been noted within a few yards of a scent station without a visit being recorded. Linhart and Knowlton (1975) also reported these phenomena, but hoped that they occurred at about the same frequency among areas and years so as not to introduce bias. They further state that indices for different areas are probably less comparable than annual trend data from the same area. However, the results shown in Table 1 were so variable, especially for the Missour Breaks areas, that it is questionable whether the scent post survey is suitable for a population index, especially when applied to relatively small areas. Futher evidence of this is available from the Nichols Coulee area where the U.S. Fish and Wildlife Service established a scent post line on the Bell Ridge Road (Fig. 2) in 1972. There were no coyote visits recorded on that line in fall, 1976, whereas we recorded an index of 47 (9 visits in 4 nights) that same fall on our line located approximately 12 miles (19.3 km) to the east. Unfortunately, the Fish and Wildlife Service has not run this line since, so futher comparisons are impossible. These reasons, plus better coyote population estimators, led to abandoning this technique in the Missouri Breaks area. Lemos (1978) also concluded that a single line of 50 stations was not sufficient to detect annual changes in coyote abundance within his study area in Oregon.

Siren Surveys - Data from these surveys are presented and discussed by Schladweiler and Pyrah (1979b) and Pyrah (1980) and won't be repeated here.

Table 1. Scent post survey indices of coyote abundance for all study areas 1975-1979.[1]

STUDY AREA LOCATION		YEAR	SEASON		
			Spring	Summer	Fall
Miles City Vicinity					
Fort Keogh		1975	59	50	74
		1976	13	144	146
		1977	58	52	63
		1978	16	10	81
Hook Ranch	Coyote Control Initiated	1975	35	53	98
		1976	38	58	80
		1977	17	11	15
		1978	12	20	47
Sixteenmile Area					
Haw Gulch		1975	-	-	214
	Coyote Control Initiated	1976	46	30	124
		1977	29	83	122
		1978	23	17	76
		1979	-	46	98
Dry Canyon		1975	-	-	87
	Coyote Control Initiated	1976	63	56	115
		1977	61	47	94
		1978	8	12	22
		1979	-	8	18
Missouri Breaks					
Wilder Trail		1975	-	-	-
		1976	86	55	62
		1977	32	61	66
		1978	17	17	109
Nichols Coulee		1975	-	-	-
		1976	59	54	47
		1977	20	14	29
		1978	35	16	15

[1]All indices prior to fall of 1976 corrected (for change in attractant used) to be comparable to those from fall 1976 and subsequent surveys.

Carcass Collections - Carcass collections in 1974-75 and 1975-76 covered most of the state in order to gather general information on sex and age ratios, food habits and reproductive performance of female coyotes of different ages. Time constraints necessitated scaling down the collection efforts in succeeding years to include only animals from on, or within the general vicinity of, actual study areas. Numbers of carcasses collected each year are shown in Table 2, along with numbers useable for various analyses.

Table 2. Results of coyote carcass collections, 1974-1980.

Year	Total Number Collected	Number useable for determination of: Sex	Age	Reproductive[1] Performance (Females only)	Food Habits
1974-75	323	322	307	134	208
1975-76	566	547	537	242	411
1976-77	59	59	58	30	42
1977-78	99[2]	129	118	42	80
1978-79	139	136	137	67	125
1979-80	60	59	58	25	37
TOTALS	1246	1244	1215	540	903

[1]Since reproductive tracts were examined soon after collection, but ages weren't determined for several months, this total includes young of the year.

[2]Skulls only were obtained from an additional 24 animals, and sex was reported for 35 animals not collected.

Sex Ratios - The sex ratio of collected animals slightly favored males in most years (Table 3). Chi-square tests of individual years data showed that none of them differed significantly from a 50:50 sex ratio ($P < 0.05$). This is in agreement with published accounts from most other studies. Where human influence was not controlling populations, reported sex ratios were generally even, or slightly favored males (see Andrews and Boggess 1978 and Berg and Chesness 1978 for recent reviews). Two exceptions to the above (Wetmore et al. 1970, Knowlton 1972) report sex ratios significantly favoring females. Human exploitation was heavy in both instances. Knowlton (1972) suggests that ingress from surrounding areas is the cause and cites earlier studies showing females tagged as pups dispersing greater distances. Subsequent studies generally confirm this (Nellis and Keith 1976, Andrews and Boggess 1978) although Berg and Chesness (1978) found that males marked as pups moved farther than females. Apparently more data is necessary before definitive conclusions can be drawn. However, it seems clear that levels of exploitation of Montana coyote populations are not sufficiently heavy to cause females to dominate the harvest, at least in the areas sampled. In light of the high prices coyote pelts commanded through most of the study, this has implications for any type of coyote management plan.

Age Ratios and Mortality - Ages of over 1,200 coyotes were determined from cementum annuli in canine teeth (Linhart and Knowlton 1967) during this study (Table 4). Although there is some question about the accuracy of this method (Allen and Kohn 1976), primarily the age at which the first cementum annulus forms, it did not appear that there were any great errors in our results. Linhart and Knowlton (1967) and Nellis et al. (1978) report that the first

Table 3. Sex ratios of coyotes collected in each year of the study.

Year	No. Animals Sexed	Percent Males
1974-75	322	54
1975-76	547	52
1967-77	59	47
1977-78	129	57
1978-79	136	50
1979-80	59	58
TOTAL	1,252	53

Table 4. Age distribution of Montana coyotes, expressed as percentages of annual samples from winter 1974-75 through winter 1979-80.

	Year and Sample Size						
Age Class	1974-75 (307)	1975-76 (537)	1976-77 (58)	1977-78 (118)	1978-79 (58)	1979-80 (58)	Total All Yrs. (1,215)
½	44.0	41.3	36.2	39.8	70.8	69.0	46.3
1½	31.9	32.8	31.0	22.9	9.5	19.0	28.2
2½	14.3	9.5	15.5	11.0	4.4	5.2	10.4
3½	5.2	5.6	10.3	7.6	6.6	1.7	5.8
4½	2.6	2.8	1.7	5.1	3.6	1.7	3.0
5½	0.7	3.0	5.2	5.1	0.7	0.0	2.3
6½	0.7	2.2	0.0	5.1	2.2	0.0	1.9
7½	0.3	1.1	0.0	1.7	1.5	0.0	0.9
8½	0.0	1.1	0.0	0.0	0.0	0.0	0.5
9½	0.3	0.2	0.0	1.7	0.7	1.7	0.5
10½	0.4	0.0	0.0	0.0	0.0	0.0	0.2
11½	0.0	0.0	0.0	0.0	0.0	1.7	0.1

distinct dark layer in the cementum becomes visible at approximately 20 months of age, while Allen and Kohn (1976) concluded that it formed much earlier, being easily visible in yearlings taken in November to January in North Dakota. Similarly, Nellis et al. (1978) detected what they determined to be a first-year annulus in some sections. Although only 2 known age teeth were sectioned in our study, both were correctly aged at 1.5 years, the age class usually questioned.

Overall, juveniles comprised 46.3 percent of our sample, ranging from 36.2 to 70.8 percent between years. The high percentage of juveniles noted in the last two winters is related to the good production and survival of pups, at least to winter, in the Missouri Breaks in those two years (see later section on reproduction). Over two-thirds of the animals collected those 2 years came from the Breaks. Yearlings ranged from 9.5 to 32.8 percent of the annual samples, averaging 28.2 percent. The low percentage of yearlings found in 1978-79 was the result of a combination of factors. Poor pup production in 1977 (see later section) was followed by a severe winter (1977-78) which probably resulted in poor survival of those pups that were produced. In addition, the average to good production in 1978 tends to swamp the older age classes.

Nearly 85 percent of our total sample was less than three years old, which is within the range for other studies reporting on large samples of animals aged (Table 5). Similarly, few animals reach older ages (6 or more).

Since our age data covers several years and many diverse areas, it is questionable whether it could be considered representative of a static population. Therefore, any conclusions drawn from it must be used with caution. However, in order to compare our data with other studies, a survival rate was calculated using the equation of Chapman and Robson (1960, as presented by Eberhardt 1969), which does assume a static population size. The calculated survival rate was 54.3 percent (mortality rate of 45.7 percent) with no apparent differences between any of the age classes. This compares with survival rates of 60.9 percent for Iowa coyotes reported by Boggess (1975) and 59.3, 71.9 and 69.9 that he calculated for data (Knowlton 1972) from Texas, New Mexico and Arizona, respectively. However, the Iowa data excluded the first age class because it was inconsistent with the assumption of a constant survival rate, and Knowlton (1972) only included adult (1 year and over) animals in his report. Knowlton (1972) estimated that the mortality rate of animals 1 year and older might exceed 40 percent annually, even among unexploited populations. Nellis and Keith (1976) estimated mortality of 36 to 42 percent (survival of 58 to 64 percent) from recoveries of animals tagged at different ages. Their mortality among age classes under 2.7 years, calculated from life tables, greatly exceeded these values. They suggested this might indicate that human-related mortality accounted for a higher percentage of young animals than natural mortality, and that natural mortality comprised a significant fraction of total mortality.

The fact that our calculated mortality rate (45.7 percent) almost perfectly matches the percentage of yearlings in our aged samples (46.3 percent) suggests that the mortality figure is probably fairly accurate. Since adult mortality rates among unexploited populations are on the order of 40 percent (Knowlton 1972) our calculated mortality rate suggests that increased human related deaths among adults are largely compensated for by decreased natural mortality rates and/or human related mortality is largely concentrated among the juvenile age class. This is similar to the conclusion of Nellis and Keith (1976).

Table 5. Ages of coyotes from different areas, expressed as the percentage of the total sampled.

Age Class	Area[1], sample size and number of years sampled. Southeastern Wyoming (225 - 1)	Southern Iowa (389 - 3)	Central Alberta (548 - 4)	Northern Minnesota (960 - 6)	Montana Statewide (1,215 - 6)
½	56.0	57.1	71.5	47.2	46.3
1½	20.4	14.9	16.6	14.7	28.2
2½	15.6	10.5	5.8	12.1	10.4
3½	5.3	8.5	0.9	8.6	5.8
4½		3.6	2.0	8.2	3.0
5½		2.6	0.9	4.3	2.3
6½		0.8	1.3	2.4	1.9
7½	2.7	1.3	0.4	1.3	0.9
8½		0.3		0.4	0.5
9½		0.3	0.5	0.4	0.5
10½		0.0		0.1	0.2
11½	-	0.3		0.1	0.1
12½	-	-		0.1	-
13½	-	-		-	-

[1]Wyoming, Iowa, Alberta, Minnesota and Montana data are from Crowe and Strickland (1975), Boggess (1975), Nellis and Keith (1976), Berg and Chesness (1978) and this study, respectively.

Regardless of whether our data meet the required assumptions of life table techniques, they do point out that Montana coyote populations are subject to high annual mortality rates. Using our calculated figure of 46 percent as the mortality rate of all animals over 1 year of age, the average mortality and survival rates of juvenile coyotes to one year of age can be calculated from our data on reproduction (from the following section) and age structures. Starting with a stable population having 100 breeding pairs with a 50:50 sex ratio (previous section), there would be 46 yearling and 54 older females. If 44 percent of the yearlings and 93 percent of the adults have litters averaging 4.5 and 4.6, respectively (see following section), a total of 297 pups would be produced. However, since only 92 (46 percent of 200) of these

(31 percent) need to survive to one year of age to replace losses of older animals, 205 young (69 percent) must die before their first birthday if a stable population is to be maintained.

Any proposed coyote management plan must take into account both the timing and extent of natural mortality, in order to make best use of available money and manpower.

Reproduction - According to Hamlett (1938) coyotes in Montana begin breeding regularly by the first of February and occasionally the last of January. His records indicate a breeding season of roughly 5 to 6 weeks, as do those of Gier (1968). Gier (1968) further reports that the range of breeding times in Kansas varied from year to year, but he found no responsible factor. Hamlett (1938) felt that environmental factors such as widely differing altitude, probably affect statewide average breeding season dates most, with individual variation among animals within an area also entering in. In regard to the latter, Young and Jackson (1951) state that young females usually whelp about 10 days to 2 weeks later than the older ones.

Male coyotes have a breeding season similar to the female, but a little longer on each end (Hamlett 1938, Gier 1968). Gier (1975) reports that old males are reproductively active from late December to early April and males of the year from late January into May. Some adult male coyotes in Arkansas apparently are capable of breeding as early as late November and early December (Gipson et al. 1975).

Reproductive performance of female coyotes of different ages (yearling and adult) examined in each year of the present study are shown in Table 6. Most of the data are from winter collections and represent placental scar counts for the previous breeding season. In some cases, however, reproductive tracts collected in late winter were useable for determining both the current and previous years reproductive performance. Although annual samples for some age groups are small, the data in Table 6 indicate a relatively high and fairly constant percentage of adults producing young each year, with high between year variability among yearlings.

Among coyotes it is generally agreed that the greatest factor affecting differences in production of young is the contribution made by the yearling age class (Knowlton 1972, Connolly and Longhurst 1975). Gier (1968) reports that food supply is the most important factor in determining breeding success of Kansas coyotes, affecting both the proportion of females that breed and the number of ova produced. The mechanism by which this occurs could work in one of two ways; either through increased food supply or reduced coyote populations. As pointed out by Connolly (1978a), regardless of which occurs the net effect is the same: more food available to each coyote. He further points out that neither food supplies nor coyote numbers are static and since both undoubtedly affect birth and death rates, it is difficult to determine which is the primary cause of subsequent fluctuations in birth and death rates of coyotes.

Gier (1975) reports that normally over 90 percent of the females 20 months or older become sexually active and a smaller proportion (0 to 60 percent) of the 9-10 month old females do so. He further reports that over 80 percent of the females contain corpora lutea in their ovaries when conditions are optimal. When conditions are poor only 50 percent of the females may ovulate (Gier 1975). Most of the time productivity would fall between these extremes.

Table 6. Results of coyote reproductive tract examinations from yearling and older animals, winter 1974-75 through winter 1979-80.

Winter of Collection	Age of Female	Number Examined	Percent with Placental Scars	Average Number of Scars/female Having Them
1974 - 75	Yearling	49	86	4.8
	Adult	34	79	4.7
	Total	83	83	4.8
1975 - 76	Yearling	84	24	3.6
	Adult	50	82	4.7
	Total	134	46	4.3
1976 - 77	Yearling	11	45	4.8
	Adult	18	89	4.8
	Total	29	72	4.8
1977 - 78	Yearling	8	0	-
	Adult	23	78	3.2
	Total	32	58	3.2
1978 - 79	Yearling	6	0	-
	Adult	18	94	4.9
	Total	24	71	4.9
1979 - 80	Yearling	6	83	5.4
	Adult	4	100	7.0
	Total	10	90	6.1
ALL YEARS	Yearlings	162	44	4.5
	Adults	149	83	4.6
	Total	311	63	4.6

Based on a small sample, Clark (1972) calculated that from 49 to 70 percent of the yearlings, and at least 97 percent of the adult females (up to 73 percent of all females) bred in 1969, a year of high rabbit populations in his Utah study area. Knowlton (1972) presents data showing highs of 81 to 91 percent of all females breeding in different areas and years. This suggests that higher percentages of yearlings, and possbily adults as well, must breed in some areas and/or years than found by Clark (1972). Several other investigators (Boggess 1975, Rogers 1965, Gipson et al. 1975, Nellis and Keith 1976 and others) examined small numbers of females from different areas for breeding condition, usually combining more than one years data. All reported results were within the ranges given by Gier (1975) for both yearlings and adults.

Results of the present study (Table 6) suggest that the average for the six years of combined data probably represent "normal" or average Montana conditions. Bearing in mind the small samples involved in some years, 1976 and possibly 1978 appear to have been normal reproductive years, with 1975 and 1977 having been poor years and 1974 and 1979 representing good years.

As previously pointed out, litter size is affected by the same factors that regulate the proportion of females which breed in any year, and conditions leading to higher pregnancy rates probably also favor larger litter size (Knowlton 1972). This relation is also apparent in our data (Table 6).

Two other things are apparent from our data on average litter size: they are generally lower than those reported from other areas; and at least in some years there are notable differences between the average litter size of yearlings and adults. Litter sizes reported in the literature are based on a variety of techniques such as counts of uterine swellings, fetuses, placental scars, or number of pups at dens. The average number of young reported per den is typically smaller than the average number based on reproductive tract examination due to uterine and postnatal mortalities, as well as failure to recover all young from each litter, particularly among older pups that may be split between two or more burrows (Knowlton 1972). Regardless of the source of the data (whether from reproductive tracts or dens) most studies reporting average litter sizes based on more than a few observations found them to generally range from 5 to 7 young (Hamlett 1938, Young and Jackson 1951, Gier 1968, Clark 1972, Knowlton 1972, Nellis and Keith 1976, Andrews and Boggess 1978, and others). Gier (1968) reports that average litter sizes in poor, average and good reproductive years would be 4.5, 5.6 and 6.4, respectively. If the assumption (in the previous section) as to which years of this study were poor, average and good is correct, our average litter sizes are considerably below those found in Kansas (Gier 1968). Our overall average is also lower than the averages reported by Hamlett (1938) for Montana earlier in the century. His study, combining several years of statewide data, showed average litter sizes of 5.7 for 71 pregnant females examined and 5.1 for 481 den litters. One or more of the following factors may be responsible for the differences between this study and that of Hamlett (1938). Environmental conditions may have been much more favorable or coyote populations much less dense prior to 1935 than at present; or preimplantation or intrauterine losses were lower than at present. It seems more logical that preimplantation and intrauterine losses would show less variation between years or periods of years than either environmental conditions or coyote densities, and therefore changes in the latter two factors are felt most likely to be responsible for the differences noted. Knowlton (1972) reports litter sizes in South Texas in relation to the intensity of coyote control efforts. Using data he presents, calculated litter sizes (based on uterine swellings) in areas of light control averaged 3.6, whereas areas of moderate control effort averaged 4.6, and those intensively controlled averaged 7.0. From this he concluded that the inverse relationship between population density and average litter size reported for other species also seems realistic for coyotes. Although it is risky to extrapolate his findings to Montana, it does appear that the period and areas sampled by our study had what would generally be considered moderate population levels (for available habitat) and were probably sustaining light to moderate man caused mortality (above natural mortality rates). It should be noted here that the production recorded for the 1979 breeding season, and to a lesser extent for 1978, is primarily related to high rodent populations on Missouri Breaks study areas, which apparently peaked in fall 1978 (also see later sections on coyote food habits and small mammal populations). Sixty-seven and eighty percent of the female reproductive tracts examined from 1978 and 1979 breeding seasons, respectively, came from Missouri Breaks areas.

Potentially significant differences in average litter size between yearling and older females were noted for the breeding seasons of 1975 and 1979 (Table 6). The difference was statistically significant (Student's t-test, $P < 0.05$) for

the 1975 sample but not for that from 1979, probably because of the small sample for the latter year. Gier (1968) reports no appreciable difference in numbers of either ova or pups produced by reproducing yearling females and older animals, nor between females of prime reproductive age (2-5 years) and those over 5 years of age. Gipson et al. (1975) found that none of 10 females they examined during their first breeding season or before their second season were pregnant or had produced pups. They further report no appreciable differences in number of ova or placental scars between coyotes that bred during their second breeding season and older females. Neither Gier (1968) nor Gipson et al. (1975), however, provide statistical evaluation for their statements. Nellis and Keith (1976) report averages of 5.2 and 6.0 placental scars for 5 yearling and 25 adult females, respectively. This difference was not statistically significant, probably because of small sample size. Despite the limited data to the contrary (from the above studies), Kennelly and Johns (1976) report that the number of corpora lutea increased significantly with age ($P < 0.05$) among their females born, or maintained from a very young age, in captivity. Corpora lutea averaged 5.6, 6.2 and 7.1 for females aged 2, 3 and 4 years old, respectively. Unfortunately, no data on yearling corpora lutea counts were presented. However, their study tends to substantiate our findings that, at least in some years, average litter size of yearlings is significantly lower than that of adults. Presumably this too would have a nutritional basis, but other factors may be important as well, and the exact mechanism involved is not understood at present.

Weights - Carcass or pelted weights (hides removed) were obtained from 268 animals from the winter 1974-75 collections. Weights of animals approaching one year of age averaged 23.4 and 26.4 pounds (10.6 and 12.0 Kg) for females and males, respectively. Carcass weights of adults (animals approaching 2 years of age or more) averaged 27.4 pounds (12.4 Kg) for females and 30.4 pounds (13.8 Kg) for males. Since there should be little difference in the proportion of the total weight comprised by the hide of winter collected animals between areas, these figures were converted to whole or live weights using the regression equation $Ny = 1.86 + 1.12\,x$ provided by Chesness (1973). Calculated whole weight averages are 28.1 pounds (12.8 Kg) for yearling females, 31.4 pounds (14.3 Kg) for yearling males, 32.5 pounds (14.8 Kg) for adult females and 35.9 pounds (16.3 Kg) for adult males. Whole weights of adult coyotes from other areas include 21.5 and 24.5 pounds (9.8 and 11.1 Kg) for California females and males, respectively (Hawthorne 1971), 25.1 and 29.6 pounds (11.4 and 13.4 Kg) for females and males in Iowa (Boggess 1975) and 26.0 and 30.7 pounds (11.8 and 13.9 Kg) for the same respective sexes in Kansas (Gier 1968). Weights of our adults average heavier than any of these, but are similar to those reported for eastern coyotes (*Canis latrans* var.) from Maine (Richens and Hugie 1974). However, their sample may have included young animals, and weights of both captive-born and hunter-killed eastern coyotes from New Hampshire which were over 6 months old averaged much heavier [39 + pounds (17.7 Kg) for females and nearly 45 pounds (20.4 Kg) for males; Silver and Silver 1969]. It is believed that eastern coyotes evolved from coyotes, with the introduction of some dog and/or wolf genes sufficiently long ago for the population to have become stabilized (Silver and Silver 1969, Lawrence and Bossert 1969), thus their heavier weights.

Although Gier (1968) found no detectable weight differences between Kansas pups of the year and older animals by December, and Berg and Chesness (1978) report no significant differences between ages, sexes or years in their Minnesota study, our findings showed significant differences between yearlings and adults

of both sexes and between sexes of each age class (t-test, $P < 0.05$). Similarly, Boggess (1975) and Richens and Hugie (1974) report significant differences between sexes of adults in Iowa and Maine, respectively.

Food Habits - Aside from the search for better methods of controlling coyotes (and hopefully their depredations on domestic livestock at the same time), no other aspect of coyote ecology has been the subject of as much interest as their food habits. A good share of this interest is also closely interwoven with the question of predation on domestic animals and/or game species, and the potential effects of this predation on the prey populations involved. This study is no different, since part of the reason for our food habits studies was to determine the timing and extent of deer and/or antelope occurrence in the coyote diet on the various study areas.

Food habits data from the first 2 winter's carcass collections (1974-75 and 1975-76) covering many different and widely separated parts of the state were presented and discussed in earlier reports (Schladweiler 1975, 1976). As a point of interest, these data are again given in Appendix B (Appendix Tables 6 and 7). These data will not be discussed further in this report, except for those samples from individual study areas which are included in the entire set of data for an area in the following discussion.

Although both stomach and scat sample analysis are valuable techniques for food habits study, each has its limitations. Both Knowlton (1964) and Meinzer et al. (1975) felt that scat analysis was the more useful technique because larger samples could be obtained from specific seasons and localities. Gier (1968), while agreeing that this was advantageous, felt that examination of scats was least useful since only nonfood remains are studied. More recently it has been recognized that not only does the digestibility of different types of food vary (Johnson and Hansen 1979), but also that larger species and/or individuals within a species are detected in scats more often than smaller ones (Weaver and Hoffman 1979). In addition the latter report also pointed out that prey as large as lagomorphs and ungulates may provide enough undigested material for many scats, further distorting the relative importance of larger prey. Factors such as these should be kept in mind in the food habits discussion that follows. Also, the data presented are only meant to give a general picture of the coyote diet on various areas, and should not be viewed as being of high precision.

Only major dietary groups are included in the following discussion because of difficulty in specific identification of many items, especially in scats. In the 1974-75 stomach samples, a carrion category was included. However, in later years this was abandoned because of the difficulty in designating carrion, especially in winter samples, and because "carrion" is often used as a draw station by trappers. Conversely, fresh carcasses used in trapping would be indistinguishable from actual prey. Therefore, after the first year, known or suspected trap bait was eliminated from the analysis for trapped animals.

Miles City Area - Analysis of scat and stomach samples from these areas (Tables 7-9), for all years are a little difficult to interpret because of the small samples involved in individual seasons, and they should not be heavily relied upon. They do have value, however, in indicating basic trends. The salient feature of this data is that mammals, especially rodents and lagomorphs were the most important year-round food of coyotes on both areas, and that deer and/or antelope were of little importance in most years and seasons having larger sample sizes. Omitting the single fall 1978 sample from the Hook Ranch,

Table 7. Food habits of coyotes on the Hook Ranch Study Area based on analysis of scats. Figures are percent frequency of occurrence/percent of total diet for major food groups only. Tr denotes less than 0.05 percent.

Year, Season, and Number of scats examined	FOOD ITEM							
			Other Mammal					
	Rodent	Lagomorph	Cattle	Domestic Sheep	Antelope	Mule Deer	Other	Total
Spring 1975 (8)	38/10.8	62/59.6	12/12.2	-	-	-	-	12/12.2
Summer 1975 (20)	45/5.4	60/49.0	5/2.5	5/4.2	10/2.6	-	-	20/9.4
Fall 1975 (32)	25/7.2	69/54.4	16/6.2	-	-	3/1.9	-	19/8.1
Winter 1975-76 (28)	36/2.4	61/46.7	39/30.8	-	18/16.4	7/3.8	-	64/50.9
Spring & Summer 1976 (6)	50/13.3	50/44.2	-	-	-	-	17/0.8	17/0.8
Fall 1976 (No Samples)	-	-	-	-	-	-	-	-
Winter 1976-77 (33)	45/21.4	58/49.7	24/10.3	6/1.2	9/7.0	15/9.8	-	45/28.3
Spring & Summer 1977 (13)	69/30.3	62/48.5	15/6.2	-	-	-	8/0.8	31/6.9
Fall 1977 (No Samples)	-	-	-	-	-	-	-	-
Winter 1977-78 (3)	33/13.3	100/85.0	-	-	-	-	-	0/0
Spring & Summer 1978 (4)	100/36.8	50/43.2	-	-	-	25/3.8	-	25/3.8
Fall 1978 (1)	100/4.0	-	-	-	-	100/50.0	-	100/50.0
Total (148 Scats)	43/12.6	61/50.5	19/11.0	2/0.8	7/5.0	7/3.7	1/0.1	34/20.7

Table 7. (Continued)

Year, Season and Number of Scats examined	FOOD ITEM						
				Vegetation			
	Bird	Reptile	Invertebrates	Fruits & Seeds	Other	Total	Miscellaneous
Spring 1975 (8)	25/0.5	-	62/12.6	-	100/2.9	100/2.9	25/1.4
Summer 1975 (20)	60/14.2	-	75/16.6	-	80/5.4	80/5.4	-
Fall 1975 (32)	22/4.8	-	62/24.1	-	56/1.3	56/1.3	-
Winter 1975-76 (28)	4/Tr	-	4/Tr	-	4/Tr	4/Tr	-
Spring & Summer 1976 (6)	50/3.3	-	83/19.2	17/1.7	67/17.5	67/19.2	-
Fall 1976 (No Samples)	-	-	-	-	-	-	-
Winter 1976-77 (33)	9/0.3	-	6/Tr	-	6/0.3	6/0.3	-
Spring & Summer 1977 (13)	46/10.0	-	54/1.2	-	23/3.1	23/3.1	-
Fall 1977 (No Samples)	-	-	-	-	-	-	-
Winter 1977-78 (3)	33/Tr	33/Tr	-	33/Tr	33/1.7	67/1.7	-
Spring & Summer 1978 (4)	75/4.2	25/7.5	50/0.8	-	75/3.8	75/3.8	-
Fall 1978 (1)	100/1.0	-	100/Tr	-	100/45.0	100/45.0	-
Total (148 Scats)	25/4.3	1/0.2	33/7.6	2/0.1	34/2.2	34/2.3	2/0.1

Table 8. Food habits of coyotes on the Hook Ranch Study Area based on analysis of stomach contents. Figures are percent frequency of occurrence/percent of total diet for major food groups only. Tr denotes less than 0.05 percent

Food Item	Year, Season and Number of Stomachs Examined			
	Winter 1976-77 (20)	Spring 1977 (5)	Spring 1978 (3)	Total (28)
Rodent	40/10.0	80/12.0	33/1.7	46/9.4
Lagomorph	50/18.6	60/30.0	67/26.7	54/21.5
Other Mammal				
Cattle	70/50.6	60/50.0	33/25.0	64/47.8
Domestic Sheep	15/7.5	-	-	11/5.4
Antelope	5/0.5	-	67/45.0	11/5.2
Mule Deer	5/5.0	-	-	4/3.6
Other	5/2.8	-	-	4/2.0
TOTAL	90/66.4	60/50.0	100/70.0	86/63.9
Bird	10/5.0	40/7.0	33/1.0	18/4.9
Vegetation				
Fruits & Seeds	-	-	-	-
Other	-	20/Tr	33/0.7	7/0.1
TOTAL	0.0	20/Tr	33/0.7	7/0.1
Miscellaneous	-	20/1.0	-	4/0.2

Table 9. Food habits of coyotes on the Ft. Keogh Study Area based on analysis of scats. Figures are percent frequency of occurrence/percent of total diet for major food groups only. Tr denotes less than 0.05 percent.

Year, Season, and Number of Scats Examined	FOOD ITEM							
				Other Mammal				
	Rodent	Lagomorph	Cattle	White-tailed Deer	Mule Deer	Antelope	Other	Total
Spring 1975 (21)	71/28.7	81/50.5	10/4.5	-	10/Tr	-	-	19/4.6
Summer 1975 (39)	46/11.8	56/35.1	13/9.4	3/2.2	3/0.1	-	-	18/11.7
Fall 1975 (49)	24/2.8	76/63.9	4/0.9	2/1.9	4/2.8	4/0.1	2/Tr	16/5.8
Winter 1975-76 (15)	60/20.6	67/50.3	-	13/2.1	20/13.3	7/2.3	-	40/17.7
Spring & Summer 1976 (14)	57/37.0	7/4.3	7/4.6	-	-	7/2.1	7/0.1	21/6.9
Fall 1976 (22)	68/29.9	32/26.9	9/2.0	-	9/5.1	-	5/0.5	23/7.6
Winter 1976-77 (10)	90/29.5	50/35.5	10/4.0	20/16.0	20/7.5	-	-	50/27.5
Spring & Summer 1977 (2)	50/27.5	-	-	-	-	50/50.0	-	50/50.0
Fall 1977 (6)	83/25.8	33/24.2	33/19.2	-	17/3.3	17/15.0	-	67/37.5
Winter 1977-78 (2)	50/50.0	50/12.5	-	50/37.5	-	-	-	50/37.5
Spring & Summer 1978 (12)	100/63.3	17/6.2	17/6.9	-	-	-	17/5.2	33/12.1
Fall 1978 (28)	100/70.5	18/13.2	21/3.2	-	4/1.8	-	-	25/5.0
Total (220 Scats)	60/27.4	50/36.1	10/4.3	3/2.0	6/2.7	3/1.2	2/0.3	25/10.6

Table 9. (Continued)

Year, Season, and Number of Scats Examined	FOOD ITEM						
				Vegetation			
	Bird	Reptile	Invertebrates	Fruits & Seeds	Other	Total	Miscellaneous
Spring 1975 (21)	29/7.2	-	5/4.8	5/1.9	48/2.3	52/4.2	-
Summer 1975 (39)	26/3.1	3/0.1	92/37.5	3/0.1	31/0.6	33/0.7	3/0.1
Fall 1975 (49)	14/0.4	2/0.1	73/26.6	-	4/Tr	4/Tr	2/0.3
Winter 1975-76 (15)	-	-	-	-	20/11.3	20/11.3	7/0.1
Spring & Summer 1976 (14)	50/1.3	36/15.9	93/33.9	-	43/0.6	43/0.6	-
Fall 1976 (22)	45/1.0	14/0.1	86/33.0	5/0.9	27/0.2	32/1.1	5/0.2
Winter 1976-77 (10)	10/1.5	-	20/5.5	-	10/0.5	10/0.5	-
Spring & Summer 1977 (2)	50/2.5	50/10.0	50/10.0	-	-	-	-
Fall 1977 (6)	33/1.5	33/2.5	50/6.8	-	17/1.7	17/1.7	-
Winter 1977-78 (2)	-	-	-	-	-	-	-
Spring & Summer 1978 (12)	67/7.2	-	58/3.3	-	75/7.7	75/7.7	8/0.2
Fall 1978 (28)	36/2.0	18/1.0	50/3.0	14/0.5	64/4.6	68/5.1	7/0.1
Total (220 Scats)	28/2.3	8/1.4	60/19.6	3/0.4	31/2.2	33/2.6	3/0.1

the only sample periods in which anything but mammals assumed importance were the spring through fall periods of 1975 and 1976. Invertebrates were relatively important on both areas during these seasons, primarily large scarab beetles in spring and grasshoppers in summer and fall. Other data from these areas also indicated that coyotes were not having any impact on the deer and antelope populations during the period of this study.

Sixteenmile Areas - Data on coyote food habits from these 2 areas were combined for several reasons: the areas were adjacent, with no physical barrier between them; many stomach samples obtained from hunters and trappers could not be assigned to one of the study areas; and small sample size for individual areas in many sampling periods. Even combining the data did not resolve the sample size problem for all sampling periods, especially (as one would expect) those after coyote control began. As was the case for the Miles City areas, mammals as a group were the most important items in the year-round coyote diet on this area (Tables 10 and 11). Considering both the scat and stomach sample data together, rodents were the most important, followed in order by mule deer, invertebrates, and approximately equal amounts of cattle and vegetation. Since slightly over 70 percent of the total sample (both sets of data together) is from fall and winter, this probably gives a slight positive bias for mule deer and a negative bias for invertebrates and vegetation to the year-round diet.

Table 10. Food habits of coyotes on Sixteenmile Study Areas (combined), based on analysis of stomach contents. Figures are percent frequency of occurrence/percent of total diet for major food groups only. Tr denotes less than 0.05 percent.

	Year, Season and Number of Stomachs Examined					
Food Item	Winter 1975-76 (10)	Winter 1977-78 (41)	Fall 1978 (8)	Winter 1978-79 (32)	Winter 1979-80 (5)	TOTAL (96)
Rodent	90/52.7	51/22.7	62/39.9	25/9.3	60/30.0	48/23.5
Lagomorph	10/2.0	12/6.5	38/27.4	12/8.8	-	14/8.2
Other Mammal						
Cattle	20/19.5	17/8.3	25/21.9	16/14.6	40/34.4	19/14.0
Mule Deer	30/25.4	61/52.6	12/0.6	59/50.6	40/35.0	52/43.7
Elk	-	7/5.1	-	16/16.7	-	8/7.5
Other	-	2/0.4	-	-	-	2/0.2
TOTAL	50/44.9	88/66.4	38/22.5	91/81.8	80/69.4	80/65.4
Bird	10/Tr	5/Tr	38/0.5	-	-	6/0.1
Vegetation	-	10/2.5	38/9.8	-	20/0.6	8/1.9
Miscellaneous	10/0.4	5/1.8	-	-	-	3/0.8

Table 11. Food habits of coyotes on Sixteenmile Study Areas (combined), based on analysis of scats. Figures are percent frequency of occurrence/percent of total diet for major food groups only. Tr denotes less than 0.05 percent.

Year, Season and Number of Scats Examined	FOOD ITEM						
			Other Mammal				
	Rodent	Lagomorph	Cattle	Mule Deer	Elk	Other	Total
Fall 1975 (100)	65/17.1	11/7.6	14/2.9	7/2.7	-	-	20/5.6
Winter 1975-76 (13)	54/18.1	15/3.4	46/38.0	62/35.5	8/5.0	-	92/78.5
Spring 1976 (13)	92/64.2	23/14.6	15/8.8	15/7.8	-	-	31/16.6
Summer 1976 (25)	84/49.0	8/5.4	24/10.1	-	8/3.6	-	32/13.7
Fall 1976 (23)	83/46.3	13/6.5	39/16.8	26/20.9	4/1.4	4/0.4	61/39.5
Winter 1976-77 (46)	63/19.0	7/5.1	11/4.9	65/50.8	9/8.3	7/5.1	83/69.1
Spring 1977 (27)	93/51.1	26/22.4	11/2.0	41/17.5	7/0.7	4/0.1	59/20.4
Summer 1977 (17)	71/28.5	41/25.5	12/10.6	12/4.1	6/4.7	12/5.8	41/25.2
Fall 1977 (11)	91/30.1	-	9/2.6	45/40.5	9/8.6	-	64/51.8
Winter 1977-78 (No Samples)	-	-	-	-	-	-	-
Spring 1978 (2)	100/33.0	50/20.0	50/45.0	-	-	-	50/45.0
Summer 1978 (13)	85/39.2	23/10.8	69/17.9	15/6.2	8/1.0	-	77/25.1
Fall 1978 (16)	56/7.6	6/2.8	50/15.6	25/8.1	12/2.8	6/0.1	88/32.1
Winter 1978-79 (9)	33/15.0	-	-	67/58.7	22/22.2	-	89/80.9
Spring 1979 (14)	93/33.7	-	29/9.0	50/16.0	29/15.1	14/5.4	100/45.6
Summer 1979 (22)	82/26.9	14/5.9	45/10.2	32/12.7	9/7.0	9/Tr	86/30.0
Fall 1979 (5)	60/37.6	-	20/0.2	20/19.4	40/34.0	20/2.8	80/56.4
TOTAL (356 Scats)	73/28.7	13/8.2	23/8.3	26/16.4	8/4.8	4/1.2	55/30.7

Table 11. (Continued)

Year, Season and Number of Scats Examined	FOOD ITEM						
				Vegetation			
	Bird	Reptile	Invertebrate	Fruits & Seeds	Other	Total	Misc.
Fall 1975 (100)	17/6.4	7/0.3	91/41.1	52/25.6	24/2.2	59/27.8	5/0.2
Winter 1975-76 (13)	-	-	-	-	-	-	8/0.1
Spring 1976 (13)	23/0.7	-	31/2.7	-	23/1.2	23/1.2	-
Summer 1976 (25)	16/1.0	-	68/17.0	36/10.6	40/3.2	68/13.8	4/0.1
Fall 1976 (23)	13/0.1	9/0.3	48/3.5	9/0.6	43/3.3	48/3.8	-
Winter 1976-77 (46)	9/4.7	-	9/Tr	-	9/1.0	9/1.0	2/1.1
Spring 1977 (27)	7/1.9	4/Tr	22/0.2	4/Tr	19/0.6	22/0.6	7/3.4
Summer 1977 (17)	47/0.5	6/0.1	76/7.6	24/4.1	41/7.8	66/11.9	29/0.8
Fall 1977 (11)	36/0.6	-	54/0.3	27/13.2	36/4.0	54/17.2	-
Winter 1977-78 (No Samples)	-	-	-	-	-	-	-
Spring 1978 (2)	-	-	50/1.0	-	100/1.0	100/1.0	-
Summer 1978 (13)	11/1.5	-	92/12.8	15/1.5	92/8.3	100/9.8	8/0.8
Fall 1978 (16)	6/Tr	-	75/51.1	-	62/11.6	62/11.6	6/0.3
Winter 1978-79 (9)	-	-	22/0.1	-	56/4.0	56/4.0	-
Spring 1979 (14)	57/5.9	-	50/2.6	21/0.1	79/10.3	86/10.4	14/1.8
Summer 1979 (22)	36/8.8	-	45/14.7	9/3.3	68/10.1	77/13.4	5/0.2
Fall 1979 (5)	-	20/3.0	40/1.0	-	60/2.0	60/2.0	-
TOTAL (356 Scats)	19/1.8	3/0.1	56/17.2	21/8.8	35/3.8	50/12.6	6/0.6

Important invertebrates were grasshopppers and crickets, with lesser amounts of other insect families being consumed. Crickets were especially prominent in fall 1978 samples. Field observation showed them to be especially abundant at this time as well.

During sampling periods when vegetation was an important dietary component, the bulk of it was fruit and seeds of a variety of species. Use of vegetation in fall 1975 included fruits and seeds of 11 species, the majority of which was gooseberry (*Ribes* spp.), with chokecherry (*Prunus virginianus*) being the only other species comprising over 1 percent of the total diet. Fruit and seed use in the summer of 1976 included only 4 species, with *Ribes* spp. again predominant, but closely followed by hawthorn (*Crataegus* spp.) and chokecherry. Fall 1977 fruit use included only 3 species, with *Rosa* spp. being most important, followed by hawthorn. Chokecherry was a minor part of the diet this fall.

Occurrence of mule deer in the coyote diet was high on Sixteenmile areas in all winters of this study (Tables 10 and 11). However, as will be discussed in a later section on mule deer, this doesn't indicate the source (carrion versus actual kills) or the impact of coyotes on the mule deer population. Although in some years coyotes were responsible for lower numbers of deer in late winter than would have occurred in the absence of predation, in other years late winter deer numbers were unaffected by the presence of coyotes or the fact that they consumed a lot of deer. In all sample periods in which both scats and stomachs were examined, mule deer remains were higher (from 7½-10 percent) in the scat samples than in the stomachs. This may indicate the magnitude of the bias introduced by such large sized prey in scat versus stomach samples, mentioned earlier.

Missouri Breaks Areas - Analysis of scat and stomach samples from these areas for all years are shown in Tables 12-14. Stomach samples (Table 13) were mostly from on or around the Wilder Trail Study Area, and should therefore resemble the scat data from that area more closely than for the Nichols Coulee area. These similarities may not be apparent for many of the sampling periods because of inadequate size of one or more samples. As noted for the other study areas, on a year-round basis mammals contributed the bulk of the food consumed on these areas, especially in winter.

Winter - Although based on a sample from which no firm conclusions can be drawn, stomachs examined from this area in winter 1974-75 contained no deer remains. This suggests that few if any deer were killed by coyotes in this area, at least during December and January. The coyote diet during winter 1975-76, however, was characterized by relatively high utilization of deer, especially mule deer. In fact, considering the 3 samples together, mule deer (at just over 28 percent), comprised the single most important coyote food item that winter, with white-tailed deer adding slightly over 3 percent more. This coincided with the documentation of substantial coyote predation on deer (both species) on these areas during this winter (Knowles 1976). Unfortunately no field studies were done here the previous year that might verify the food habits information. A comparison between the number of definite and probable coyote-killed deer of both species, and the percentage each comprised of the coyote diet from this area, is presented in Figure 5 for the winters of 1975-76 through 1979-80. A fairly close relationship between the two is apparent, especially for mule deer, although some discrepancies do occur. This suggests that adequate winter scat samples might be useable as an indicator of the general magnitude of coyote predation on deer in this area.

Table 12. Food habits of coyotes on the Wilder Trail Study area based on analysis of scats. Figures are percent frequency of occurrence/percent of total diet for major food groups only. Tr denotes less than 0.05 percent.

Year, Season and Number of Scats Examined	FOOD ITEM								
			Other Mammal						
	Rodent	Lagomorph	Cattle	Mule Deer	White-tailed Deer	Antelope	Elk	Other	Total
Winter 1975-76 (21)	29/3.4	14/14.2	14/9.9	62/53.2	-	10/9.5	-	-	86/72.6
Spring 1976 (No Samples)	-	-	-	-	-	-	-	-	-
Summer 1976 (6)	100/48.8	17/14.2	17/1.7	-	-	17/10.0	-	-	33/11.7
Fall 1976 (43)	44/26.4	21/18.6	12/5.0	9/3.7	-	7/3.3	26/17.4	-	53/29.4
Winter 1976-77 (68)	62/34.7	44/37.4	16/9.5	10/4.7	7/5.5	3/1.7	4/2.1	1/0.1	40/23.5
Spring 1977 (26)	62/35.2	27/23.6	31/16.8	8/0.3	-	-	-	-	38/17.1
Summer 1977 (52)	44/7.4	23/13.5	19/9.5	4/3.7	-	-	2/0.1	2/Tr	27/13.2
Fall 1977 (16)	69/32.9	31/23.9	12/6.6	6/6.2	-	6/3.4	-	6/1.2	31/17.5
Winter 1977-78 (30)	80/33.0	17/12.7	40/14.8	30/15.7	3/3.3	13/6.6	-	3/Tr	73/40.4
Spring 1978 (13)	92/41.1	15/2.7	23/6.3	-	-	15/7.2	-	31/2.7	54/16.2
Summer 1978 (86)	95/35.8	16/4.3	42/6.8	5/Tr	-	1/0.3	-	2/Tr	45/7.1
Fall 1978 (154)	98/66.8	11/4.3	7/0.9	6/1.1	1/Tr	2/0.5	3/0.9	2/0.3	18/3.8
Winter 1978-79 (23)	96/76.9	39/15.0	17/1.5	13/5.8	-	4/Tr	-	-	35/7.3
Spring 1979 (34)	94/89.1	9/2.4	6/0.1	3/0.6	-	-	-	-	9/0.6
Summer 1979 (130)	99/72.0	16/6.2	5/0.6	2/0.1	-	-	2/0.5	1/Tr	10/1.3
Fall 1979 (21)	100/75.0	14/4.3	14/1.5	14/0.1	-	10/1.9	10/2.6	5/0.2	48/6.3
TOTAL (723 Scats)	82/50.2	20/11.3	16/4.9	8/3.8	1/0.7	3/1.4	3/1.6	2/0.2	28/12.4

Table 12. Continued.

Year, Season and Number of Scats Examined	FOOD ITEM						
				Vegetation			
	Bird	Reptile	Invertebrate	Fruits & Seeds	Other	Total	Miscellaneous
Winter 1975-76 (21)	14/9.0	-	24/0.8	-	-	-	-
Spring 1976 (No Samples)	-	-	-	-	-	-	-
Summer 1976 (6)	50/1.0	-	67/24.2	17/Tr	17/0.2	33/0.2	-
Fall 1976 (43)	9/0.4	5/1.0	63/21.7	-	14/2.5	14/2.5	2/Tr
Winter 1976-77 (68)	16/2.2	-	6/Tr	1/Tr	1/1.2	1/1.2	7/1.0
Spring 1977 (26)	23/2.5	8/0.6	50/20.0	-	19/1.1	19/1.1	-
Summer 1977 (52)	56/4.1	10/2.4	56/2.9	75/54.3	23/2.1	88/56.4	6/0.1
Fall 1977 (16)	19/0.9	-	56/10.6	31/4.9	62/7.9	62/12.8	6/1.2
Winter 1977-78 (30)	17/5.9	-	10/Tr	13/1.8	43/3.3	50/5.1	13/2.9
Spring 1978 (13)	54/14.0	15/1.2	62/9.8	15/Tr	85/12.1	85/12.1	15/3.1
Summer 1978 (86)	43/2.3	3/1.3	81/6.2	55/36.2	84/5.3	92/41.6	14/1.4
Fall 1978 (156)	16/1.3	12/0.9	77/5.3	58/12.3	66/4.5	88/16.8	10/0.8
Winter 1978-79 (23)	-	-	17/0.1	-	39/0.8	39/0.8	-
Spring 1979 (34)	12/0.3	-	44/0.5	9/2.4	97/4.6	97/6.9	6/0.1
Summer 1979 (130)	18/1.4	5/0.2	65/3.2	26/8.5	60/4.7	85/13.3	18/2.5
Fall 1979 (21)	10/0.7	-	33/0.3	38/2.6	67/10.4	95/13.0	10/0.3
TOTAL (723 Scats)	22/2.2	5/0.6	55/5.3	32/12.8	51/4.0	67/16.7	10/1.1

Table 13. Food habits of coyotes on Missouri Breaks Study Areas based on analysis of stomach contents. Figures are percent frequency of occurrence/percent of total diet for major food groups only. Tr denotes less than 0.05 percent.

Year, Season and Number of Stomachs Examined	FOOD ITEM								
			Other Mammal						
	Rodent	Lagomorph	Cattle	Mule Deer	White-tailed Deer	Antelope	Elk	Other	Total
Winter 1974-75 (12)	83/33.8	17/44.8	17/6.3	-	-	-	-	8/Tr	25/6.3
Summer 1975 (3)	100/8.3	-	-	-	-	-	-	-	-
Winter 1975-76 (40)	55/24.3	18/13.2	25/17.8	35/24.4	10/7.7	-	2/1.9	-	70/51.8
Summer 1976 (3)	67/3.7	-	-	-	-	-	-	-	-
Winter 1976-77 (14)	71/38.7	36/21.4	21/10.4	21/9.6	-	-	-	-	43/19.9
Fall 1977 (7)	57/17.3	14/11.4	29/24.3	57/21.3	-	-	-	-	71/46.5
Winter 1977-78 (24)	54/36.8	33/30.2	8/3.3	21/14.0	-	8/4.2	-	-	38/21.4
Summer 1978 (2)	100/54.5	-	50/2.5	-	-	-	-	-	50/2.5
Winter 1978-79 (83)	81/57.4	20/14.9	29/18.6	10/4.1	-	6/2.8	-	-	45/25.4
Winter 1979-80 (32)	78/66.9	16/15.0	12/11.1	9/5.1	-	6/1.9	-	-	28/18.0
Total (220 Stomachs)	72/45.3	20/17.7	22/13.9	17/9.5	2/1.4	4/1.8	1/0.3	1/Tr	45/27.0

Table 13. Continued.

Year, Season and Number of Stomachs Examined	FOOD ITEM						
				Vegetation			
	Bird	Reptile	Invertebrate	Fruits and Seeds	Other	Total	Miscellaneous
Winter 1974-75 (12)	33/3.4	-	33/0.2	-	58/0.2	58/0.2	50/11.3
Summer 1975 (3)	100/23.3	-	100/68.3	-	-	-	-
Winter 1975-76 (40)	12/5.8	-	2/Tr	-	12/0.1	12/0.1	22/4.9
Summer 1976 (3)	67/59.7	-	100/35.0	-	67/1.7	67/1.7	-
Winter 1976-77 (14)	29/14.6	-	7/5.4	-	-	-	-
Fall 1977 (7)	14/4.3	-	-	14/2.9	14/4.3	29/7.1	14/4.3
Winter 1977-78 (24)	21/5.8	-	-	-	4/0.1	4/0.1	12/5.6
Summer 1978 (2)	50/20.0	50/2.5	100/1.5	100/19.0	-	100/19.0	-
Winter 1978-79 (83)	18/0.7	-	-	4/0.2	-	4/0.2	4/1.3
Winter 1979-80 (32)	6/0.1	-	-	-	-	-	-
Total (220 Stomachs)	19/4.6	1/Tr	6/1.8	3/0.4	7/0.2	10/0.6	10/3.1

Table 14. Food habits of coyotes on the Nichols Coulee Study Area based on analysis of scats. Figures are percent frequency of occurrence/percent of total diet for major food groups only. Tr denote less than 0.05 percent.

Year, Season and Number of Scats Examined	FOOD ITEM									
						Other Mammal				
	Rodent	Lagomorph	Cattle	Domestic Sheep	Mule Deer	White-tailed Deer	Antelope	Elk	Other	Total
Winter 1975-76 (95)	59/29.3	24/20.4	12/5.0	2/1.3	37/24.4	5/2.4	16/11.7	3/2.0	1/0.1	76/46.9
Spring 1976 (16)	62/30.3	31/19.6	38/23.2	-	6/6.2	-	-	-	-	44/29.4
Summer 1976 (30)	47/15.3	23/12.5	27/9.9	3/2.3	10/3.7	-	3/0.3	-	-	43/16.3
Fall 1976 (10)	60/32.6	10/4.0	30/27.9	-	-	-	-	-	-	30/27.9
Winter 1976-77 (46)	39/17.2	33/26.3	11/8.4	-	28/23.0	7/6.1	11/6.6	7/2.9	9/8.7	72/55.7
Spring 1977 (7)	43/15.7	43/42.9	29/10.7	-	-	-	14/13.6	-	-	43/24.3
Summer 1977 (21)	43/8.0	5/4.7	5/Tr	-	-	-	-	-	-	5/Tr
Fall 1977 (2)	100/50.0	50/40.0	-	-	-	-	-	-	-	-
Winter 1977-78 (14)	71/16.6	64/38.3	29/11.4	-	29/11.1	-	14/10.4	-	-	57/32.9
Spring 1978 (No Samples)	-	-	-	-	-	-	-	-	-	-
Summer 1978 (9)	100/34.4	22/4.6	11/1.1	11/2.2	11/Tr	-	11/2.8	-	-	44/6.1
Fall 1978 (69)	78/27.6	12/4.8	23/4.2	1/1.4	6/0.5	-	1/Tr	-	1/Tr	33/6.3
Total (319 Scats)	60/24.0	24/16.5	18/7.4	2/1.0	19/11.8	3/1.6	8/5.3	2/1.0	2/1.3	52/29.4

Table 14. Continued.

Year, Season and Number of Scats Examined	FOOD ITEM						
				Vegetation			
	Bird	Reptile	Invertebrate	Fruits and Seeds	Other	Total	Miscellaneous
Winter 1975-76 (95)	11/2.2	-	14/0.3	7/0.5	8/0.4	16/0.9	2/Tr
Spring 1976 (16)	19/1.1	19/3.1	62/14.8	-	31/0.8	31/0.8	12/1.0
Summer 1976 (30)	43/0.7	20/0.3	87/36.3	37/17.0	27/0.6	63/17.6	13/1.1
Fall 1976 (10)	-	20/0.5	60/34.5	-	10/0.5	10/0.5	-
Winter 1976-77 (46)	11/0.6	-	9/0.1	2/Tr	-	2/Tr	2/0.1
Spring 1977 (7)	-	-	29/13.6	-	29/2.1	29/2.1	14/1.4
Summer 1977 (21)	38/3.4	19/0.9	67/0.9	90/81.6	38/0.6	100/82.1	10/0.1
Fall 1977 (2)	-	-	50/3.5	-	100/6.5	100/6.5	-
Winter 1977-78 (14)	21/1.2	-	14/Tr	21/0.8	71/9.1	79/9.9	7/1.1
Spring 1978 (No Samples)	-	-	-	-	-	-	-
Summer 1978 (9)	44/1.7	44/3.1	78/16.1	56/15.7	56/5.6	89/21.2	67/12.8
Fall 1978 (69)	28/1.2	9/0.8	81/16.9	61/34.3	48/5.2	87/39.6	17/2.9
Total (319 Scats)	20/1.4	8/0.5	44/9.8	28/15.0	26/2.0	45/17.1	10/1.3

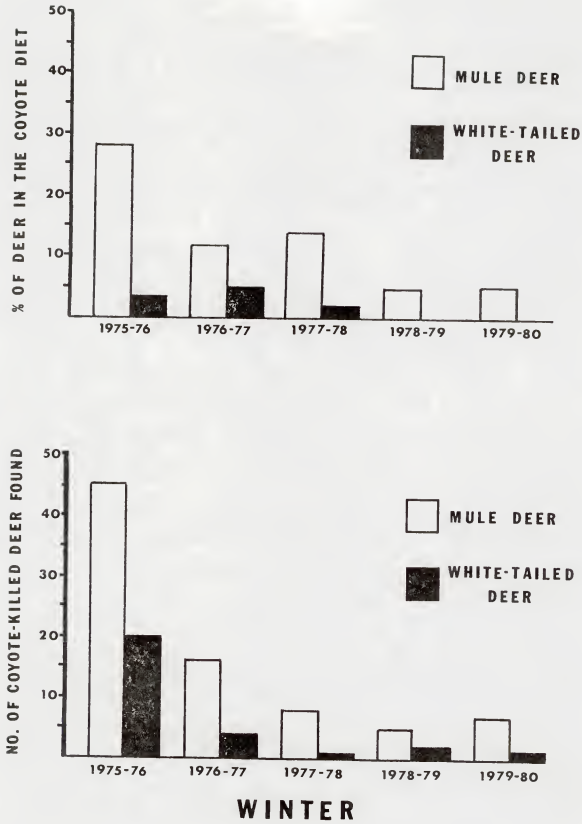

Figure 5. A comparison between the number of definite and probable coyote-killed deer found in the Missouri Breaks areas during the winters of 1975-76 through 1979-80, and the percentage of deer remains in the coyote diet for this general area during the same winters.

During 1976-77 through 1979-80, inclusive, mule deer comprised roughly 12, 14, 4.5 and 5 percent, respectively of the winter coyote diet, based on all 3 samples for a given winter. White-tailed deer made up only 5, 1.5, 0 and 0 percent of the diet during these same 4 winters, respectively.

In all winters except 1975-76, rodents or lagomorphs constituted the most important coyote food for this area, and combined they formed from 55 to about 82 percent of the total winter diet, considering all samples together. Even in 1975-76 these two combined to make up over 42 percent of the diet although mule deer ranked first overall. Excluding 1974-75's small sample, lagomorph remains constituted roughly 15-32 percent of the diet, being highest in 1976-77. At the same time, rodent use increased each winter between 1975-76 and 1979-80, comprising over 60 percent of the diet in the last 2 winters. Cattle (*Bos taurus*) was the only other relatively important animal in the winter diet in all years varying from about 9-15 percent between years (excluding 1974-75).

Antelope were a minor dietary item in most winters, but contributed about 6.5 and 8 percent of the total diet during 1977-78 and 1975-76, respectively. Although a herd of antelope which became isolated in breaks habitat in the northwest part of the Wilder Trail Study Area in the severe winter of 1978-79 was preyed on heavily by coyotes (see antelope and coyote predation sections), this was not detected in our food habits analysis. The relatively small part of the overall area they inhabited is the probable cause. Antelope are admirably equipped to avoid predators in their normal prairie habitat, and unless conditions are unusual they probably do not represent an important source of food for coyotes during winter. This might not apply where young fawns are the prey.

Spring through fall - Coyote food habits in the Missouri Breaks during warmer months were characterized by utilization of a wide variety of items, apparently dictated by availability (as possibly tempered by preference). With the constraints of often limited sample sizes in mind, the following generalizations can be made for the spring through fall food habits of coyotes in this area. Similarities in basic trends between the individual study areas allows discussing them together, but where they occur, possibly important between-area differences will be pointed out. Where only one of the study areas is represented in a seasonal sample, it will be assumed that this represents, at least generally, the food habits of coyotes throughout the area.

During 1976 invertebrates were relatively important throughout the spring-fall period, followed by rodents, other mammals and lagomorphs. Fruits and seeds, primarily of chokecherry, were important on the Nichols Coulee area during this summer, but not on the Wilder Trail area. This is probably related to the small number of scats obtained on the latter area.

The following year (1977) rodents and lagomorphs dominated the spring diet, with lesser amounts of other mammals and invertebrates being consumed. The most striking feature of the summer diet was a dramatic shift to fruit use on both areas. This was primarily chokecherry, and most other food groups were relatively unimportant by comparison. By fall the diet had shifted back to about what it had been that spring.

High utilization of rodents characterized the coyote diet throughout the warmer months of 1978, especially on the Wilder Trail area. Fruit was important

in summer and fall on both areas. Summer fruit use on the Wilder Trail area was mostly chokecherry, while *Rosa* spp. predominated on the Nichols Coulee area. Fruit use during fall was primarily *Rosa* spp. on both areas. Invertebrates were also important during summer and fall of this year, especially on the Nichols Coulee Study area.

Although only the Wilder Trail area was sampled in 1979 the high rodent use noted (to the point that all other foods were relatively unimportant throughout the spring through fall period) was assumed to have been similar on the Nichols Coulee area. This is considered valid since the high utilization coincided with increased small mammal populations which occurred simultaneously on both areas (see small mammal section).

The following discussion attempts to relate some of our findings with food habits studies from other areas. Despite the fact that many studies are cited below, many additional reports were reviewed and although they are not cited here they largely form the basis for some of the generalizations that are made.

Coyotes are versatile and extremely adaptable in regards to food habits, quickly altering their feeding patterns to adjust to changing conditions, and apparently feeding on whatever is most convenient. This opportunistic character of the coyote is probably largely responsible for its successfully surviving, and even greatly expanding its range, in the face of habitat changes and human persecution. That coyote diets vary on a local, seasonal and annual basis is almost universally recognized by most workers reporting on food habits. Fichter et al. (1955) recognized and pointed out these factors and also cautioned that lumping of data could obscure possibly important local patterns while generalizations can often be misleading. These factors make it somewhat meaningless to spend a lot of time on comparisons between this and other food studies. Some comparisons, however, are worthwhile and necessary to an understanding of the role of the coyote in relation to various prey species.

Another almost universal truth to be found in reported coyote food habits studies is that mammals provide by far the greatest part of the year-round diet. Rodents and lagomorphs are normally among the most important food items documented, at least on a year-round basis, with one or the other usually ranking first in importance and the other ranked not far behind. Seasonally, there is usually greater diversity and these items often rank a bit lower, although even then they generally rank near the top.

Although most of the deer use noted during this study occurred during winter, three distinct peaks of deer consumption are reported by Sperrry (1941) from his examination of 8,339 coyote stomachs containing food which were collected in the 17 western states. These occurred in late winter, in the fawning period and in the hunting season. However, the amount of deer remains he found (6 percent frequency of occurrence, and 3.6 percent of the volume) was relatively small on a year-round basis. Bond (1939) found deer in 26.1 percent of the scats (273) and stomachs (9) he examined from northeastern California. Ferrel et al. (1953) found deer remains in 18.5 percent of 2,222 stomachs examined from throughout California which contained food, and it formed 13.8 percent of the volume on an annual basis. Yet another California study (Hawthorne 1972) reports the occurrence of deer in 35.2 percent of 384 scats, forming 25 percent of the year-long diet. Most of the deer eaten in this latter study was felt to be carrion.

Several other studies (Ozoga 1963, Ozoga and Harger 1966, Niebauer and Rongstad 1975, Hamilton 1974 and Berg and Chesness 1978) report a high incidence of deer remains in coyote stomachs and/or scats, especially during winter and early spring when it might represent over half of the total food volume. These studies cover northern areas where, with one possible exception, the deer are subject to periodic if not annually severe winter conditions. These studies also generally agree that although coyotes can and do kill some deer in these areas, most deer in the coyote diet was carrion resulting from the hunting season or winter-kills. Niebauer and Rongstad (1975) found that coyotes consumed significantly different ($P < 0.001$) amounts of deer in the spring following a severe winter than they did after a mild one. Much of the late spring and summer deer use noted in these studies was of fawns, and peak utilization coincided with the peak in fawning. Although none of these particular studies tried to assess the impact of the coyote on fawn survival, this is discussed in some detail later.

The high seasonal use of invertebrates noted in some areas during our study consisted primarily of grasshoppers (including crickets also) and beetles. Lesser amounts of other insects, and in a few cases other invertebrates such as snails, were recorded. Our data suggest that whenever and wherever relatively large terrestrial insects become abundant coyotes are quick to exploit this food bonanza.

Extensive and widespread use of insects such as we found is seldom reported and therefore was a somewhat unexpected phenomena. Gier (1968) presented no data but stated that from direct observation and scat analysis, insects (primarily grasshoppers, crickets and large beetles) constituted a major part of the diet of some coyotes in summer, and that grasshoppers became especially prevalent in the fall after the first few frosts. Murie (1940) reported insects (primarily grasshoppers and Mormon crickets) in nearly 17 percent of 5,086 scats from Yellowstone National Park and considered them an important and highly palatable food since they were taken in large quantities when much other food was available. Similarly, Bond (1939) reported insects, again mostly grasshoppers, in nearly 20 percent of the scats and stomachs examined from Lava Beds National Monument, California. Insects occurred in 25, 74, 39 and 18 percent of the spring through winter samples, respectively, in 2,353 scats seasonally analyzed by Fichter et al. (1955). Insects were common in the spring through fall diet of Arkansas coyotes (Gipson 1974) and occurred in 11 percent of the year-round sample of 168 stomachs collected over a several-year period. Neither Murie (1940) or Bond (1939) provided a seasonal breakdown, and none of these studies presented any type of volumetric determination.

Insects were recorded in every month of Sperry's (1941) monumental study, with the largest volume (3 percent) occurring in July. Korschgen (1957) examined 770 coyote stomachs from Missouri and found insects to comprise 1.9 and 3.5 percent of the volume of summer and fall samples, respectively. Ferrel et al. (1953) reported seasonal coyote food habits for each of 5 different areas of California. Insects bulked from a trace to 11.6 percent of the summer volume and 0.3 to 7.7 percent of the volume in fall samples. Knowlton (1964) analyzed 265 stomach samples and 2,590 scats from south Texas and reports that coyotes fed on insects according to seasonal abundance as modified by availability of other foods. Insects were taken infrequently during winter and spring, but increased to over 40 percent of the diet in fall when fruits were no longer available. Meinzer et al. (1975) found insects to comprise 21.9 percent of the volume of scats and 38.6 percent of the volume of stomach samples of coyotes from the Rolling Plains of Texas during spring and summer.

As is the case with invertebrates, utilization of fruits is also greatly influenced by availability. Fruit availability is quite limited on Miles City Study Areas and fruit was seldom encountered in samples from that area. Conversely, fruits of a wide variety of shrubs were seasonally available on Sixteenmile Areas in certain years, and were heavily used in late summer and fall in those years. Generally speaking, variety and availability of fruits on Missouri Breaks Areas is intermediate between the other two areas, although it is highly important when present in volume.

Although comparatively few studies report fruit to be an important part of the year-round diet, it does appear in the diet more frequently in significant amounts, than do insects. Gier (1968) reports that fruits are eaten in quantity by some if not most coyotes. Murie (1940) felt that where available, fruit was eaten in large quantities, but he found little use of this item because of limited berry abundance in Yellowstone National Park. Sperry (1941) found wild fruits to supply only a small portion (2 to 4 percent) of the July through October volume of foods in the stomachs he examined. Ferrel et al. (1953) report wild fruit as making up less than 2 percent of the volume of stomachs in all seasons and areas of California with 3 exceptions. These all occurred in fall and fruit formed 5.3, 5.9 and 19.7 percent of the volume in these 3 areas. Similarly, fruits were important in the diet of Missouri coyotes only in fall, when they formed 6.5 percent of the diet by volume, with persimmon (*Diospyros virginiana*) accounting for 70 percent of the total (Korschgen 1957). Persimmon was also reported to rank high in volumetric determination of coyote food habits in northwestern Louisiana (Michaelson 1975) forming over 15 percent of the volume of 71 stomachs, but less than 3 percent of the volume of 130 scats. The year-round diet of northwestern Wisconsin coyotes, based on analysis of 3,353 scats and 208 stomachs spanning 3 spring through fall and 2 winter periods included 17.4 percent fruit by volume. All fruit use occurred in summer (27 to 44 percent utilization between years) and fall (3 to 9 percent annual variation). Sperry (1941), Ferrel et al. (1953), Korschgen (1957) and Michaelson (1975) also report additional but lesser amounts of cultivated fruits taken.

Pond (1939) found gooseberries to be a major part of the late July-early October diet in northeastern California, and Fichter et al. (1955) found fruits in 79 percent of their fall collected scats in Nebraska. Gipson (1974) found fruits and seeds of wild plants, especially persimmon, in 29 percent of 168 stomachs collected during all seasons in Arkansas, ranking it second in the year-round diet. Persimmon was the most common autumn food, and fruits and seeds of cultivated plants were found in an additional 7 percent of his year-round stomach samples. These latter studies cannot be directly compared to our data because no volumetric determination of the contribution fruit made to the overall diet was presented.

Knowlton (1964) found two peaks of fruit utilization in south Texas, one in spring and another in late summer and fall. During peak utilization one year fruit comprised 56 and 43 percent of the spring and summer diets, respectively, while the following spring it barely exceeded 20 percent because unfavorable weather practically eliminated fruiting of the two most frequently eaten species.

Another Texas study (Meinzer et al. 1975) found that fruits of 9 species of native plants collectively contributed 46 percent of the mean annual diet. It is apparent from their figures that in some months these fruits exceeded 90 percent of the diet.

Several authors (Gier 1968, Fichter et al. 1955 and Knowlton 1964) mention that increased availability of insects and/or fruits tend to reduce predation pressure by coyotes on other prey. It has been speculated (Fichter et al. 1955, Knowlton 1968, Miehner and Rongstad 1975 and Meinzer et al. 1975) that when these foods are in short supply higher predation on birds, game animals and domestic livestock might result.

Coyote Control

As previously discussed, experimental removal of coyotes was planned on one of each pair of study areas following two years of data collection. In all cases it was decided to delay our control efforts until late winter when fur values had declined and people pursuing coyotes for pelts had essentially quit hunting and trapping.

Hook Ranch - Control was initiated on this areas in late winter 1976-77. A known minimum removal of 25 coyotes from and adjacent to the study area occurred prior to our control efforts; the actual take was probably much greater. Project personnel removed 14 coyotes during 19.0 hours of helicopter hunting time during March and April, 1977. Ferry time to and from the Miles City area accounted for an additional 1.8 hours. Other control efforts included placement of 7 M-44 devices in the field for a total of 25 days each in April and May, 1977. No coyotes were taken with these devices, and only one was triggered, apparently by a skunk or badger, probably the latter.

Coyote control was continued on this area in late winter 1977-78. A large aerial hunting effort occurred here prior to our efforts, but no actual take figures could be obtained. Project control efforts on this area included a total of 12.3 hours of helicopter hunting (plus 1.4 hours of ferry time) on 13 March and 3 May, 1978, and resulted in the removal of the only 3 coyotes seen. Due to the small number of coyotes encountered other control efforts were considered unnecessary to meet the desired level of coyote population reduction.

Although experimental coyote control was terminated on this area after early May, 1978, it was known that fairly intensive aerial hunting was again conducted here during winter 1978-79. A helicopter survey of deer and antelope on this area in late March 1979 revealed no coyotes in approximately 4 hours of flying time. This contrasted with 8 coyotes observed on the Ft. Keogh area on the following day in approximately 2½ hours of helicopter flying under identical conditions.

Sixteenmile Area - Although the two Sixteenmile areas are adjacent to one another and intensive control on one would probably affect the coyote population on the other, control was tentatively scheduled for only one of these areas in winter 1977-78. As previously pointed out, helicopter hunting occurred on both areas in late November, 1977, and approximately 35 coyotes had been removed by the time it was learned that this hunting was occurring. Since further commitments for hunting and trapping had been made, it was decided to proceed by using the entire area as a coyote control area as previously described. The approximate known removal between late November and mid-February was 115 coyotes. The only control effort by project personnel removed an additional 9 coyotes during 6.0 hours of helicopter hunting (plus 2.7 hours of ferry time) on 10 March 1978.

The following winter (1978-79) the known removal from this area was approximately 25 coyotes in late fall-early winter. Coordination with the local District Field Agent (U.S. Fish and Wildlife Service) led to the removal of an additional 25 animals in late February, using a helicopter. Although further control was anticipated, the coyotes dispersed to higher, more timbered areas before it could be carried out. Despite this, it was felt that the objective of a 50 percent minimal reduction in coyotes was achieved for this area.

Although no cost:benefit analysis will be attempted here, cost of coyote control (helicopter hunting) during this period, using the current rate of $60.00 per hour for the Department of Fish, Wildlife and Parks helicopter, would have averaged $86.00 per coyote taken (range of $40.00-$246.00). These figures do not include salaries of pilot or gunner, nor any ferry time. Although some revenue was obtained from the hides of coyotes taken, many were of no value because of the late date they were taken. The capricious nature of the fur market would not make this a dependable factor in any economic analysis.

BIG GAME

Antelope - Antelope regularly inhabit only the Wilder Trail, Hook Ranch and Ft. Keogh study areas. The number observed on and near the latter area was generally relatively small (less than 50), primarily due to limited habitat availability. Table 15 shows results of antelope classification flights from these areas.

The winters of 1977-78 and 1978-79 were two of the most severe winters the eastern part of Montana had experienced for at least 20 years (Hamlin 1979). Severe winter weather caused extensive movements in some areas, especially in 1978-79, and light to relatively heavy overwinter mortality in both years. Region 7 personnel examined 189 antelope winter-killed during 1977-78 in several hunting districts, including the Hook Ranch Study Area. Although the Hook Ranch undoubtedly suffered some winter mortality, it was in an area of lower overall loss than other portions of the area checked (Wentland 1978).

Although movement off the Ft. Keogh area apparently occurred in winter 1977-78 (no antelope found), major movements were more noticeable in all areas the following winter. In addition to outright losses on the Hook Ranch, most animals left this area in winter 1978-79. At the same time, more animals were found on the Ft. Keogh area than at any prior time, and an influx of antelope into breaks habitat on the Wilder Trail Study Area occurred. The latter apparently came from north of the Missouri River or west of the study area into what was apparently emergency winter habitat, and were preyed on fairly heavily by coyotes (Schladweiler and Pyrah 1979b). The fact that this area constitutes good coyote habitat, was terrain unfamiliar to these antelope, and was coupled with deep snow and severe cold, put the antelope at a decided disadvantage. Whether survival was appreciably lower than would have been the case without coyote predation is conjectural, the point being that this was an unusual situation and overwinter mortality would have been high regardless. Antelope classifications (Table 15) show that fawn:doe ratios have varied considerably between years. However, where sample size of animals classified is large enough to be meaningful, there is no apparent relationship between fawn:doe ratios and coyote control (Hook Ranch) or lack thereof (Ft. Keogh and Wilder Trail).

Table 15. Results of antelope classifications on various study areas. Data prior to 1975 was obtained from Region 4 and 7 files. All data are from fixed wing aerial flights except those marked (H) which were helicopter flights.

Season & Year	HOOK RANCH[1/]				FT. KEOGH[2/]				WILDER TRAIL[3/]			
	Bucks	Does	Fawns	Fawns: 100 Does	Bucks	Does	Fawns	Fawns: 100 Does	Bucks	Does	Fawns	Fawns: 100 Does
Summer 1964	–	–	–	–	–	–	–	–	827	1,439	1,076	75
Summer 1966	–	–	–	–	9	4	3	75	816	1,143	1,024	90
Summer 1967	38	72	58	81	–	–	–	–	–	–	–	–
Summer 1969	–	–	–	–	4	23	21	91	303	674	607	90
Summer 1970	34	74	67	91	–	–	–	–	429	802	701	87
Summer 1971	38	53	49	92	–	–	–	–	–	–	–	–
Summer 1972	–	–	–	–	3	23	15	65	–	–	–	–
Summer 1973	104	184	104	57	–	–	–	–	500	1,243	890	72
Summer 1974	–	–	–	–	20	18	14	78	47	152	29	19
Summer 1975	63	107	77	72	12	18	12	67	573	1,204	931	77
Winter 1975-76(H)	29	58	27	47	5	9	6	67	–	–	–	–
Summer 1976	25	49	33	67	7	48	33	69	111	303	175	58
Winter 1976-77(H)	36	109	83	76	–	–	–	–	–	–	–	–
Summer-Fall 1977	6	28	23	82	3	12	9	75	140	307	204	66
Winter 1977-78(H)	1	7	5	71	NONE OBSERVED				–	–	–	–
Summer-Fall 1978	29	116	95	82	2	10	9	90	450	1,128	784	70
Winter 1978-79(H)	7	13	17	131	19		13	–	–	–	–	–
Fall 1979	15	77	52	68	5	8	5	62	–	–	–	–

1/ Summer 1973 figures are the results of 3 flights, 1 each in July, August and September, and summer-fall 1977, winter 1977-78 and fall 1979 flights also included 134, 123, and 40 unclassified animals, respectively.

2/ Winter 1975-76 and 1978-79 flights also included 9 and 55 unclassified animals, respectively, and summer 1976 figures are from 2 flights combined.

3/ Figures are for all of antelope hunting district 481 except 1974 which includes only a sample for fawn production, and 1976 and 1977 which include only the Wilder Trail Study Area.

White-Tailed Deer - Whitetails occur on the Ft. Keogh Study Area and along the Missouri River between the Nichols Coulee and Wilder Trail Study Areas. Population levels of white-tailed deer in the latter area over the last several years are reported in more detail by Hamlin (1980a). He further reports that in recent years fawn survival in this population has followed the same trend as for mule deer in adjacent uplands, and that a common factor may be affecting both species. For this reason, and because the white-tailed deer were less intensively studied, it will be assumed that their population trend corresponds to that of mule deer populations in the same area (discussed in more detail later) and they will not be discussed further here.

White-tailed deer on the Ft. Keogh area were difficult to locate except with the aid of a helicopter during winter. With the exception of winter 1977-78, when 61 whitetails (41 adults and 20 fawns) were classified in late winter, the number of animals classified on individual flights numbered 30 or less. Although it is risky to draw conclusions from such scanty data, it appeared that winter severity was a more important factor in regulating number of deer on this area than was the coyote population level. The two lowest fawn:adult ratios (49 and 50 fawns:100 adults) occurred in late winter of 1977-78 and 1978-79, respectively, the two most severe winters recorded in years. Fawn: adult ratios from other flights ranged from 67 to 111 fawns per 100 adults, more than adequate for population maintenance, again keeping in mind the small samples involved.

Mule Deer - Mule deer classification flights on Miles City areas (Table 16) generally resulted in few deer observations except during late winter helicopter flights. Comparisons between areas show similar between-year trends, with the effects of the severe winters of 1977-78 and 1978-79 being especially apparent. As with the antelope on these areas, the mule deer seemed more affected by the severe winter weather than by whether or not coyotes were controlled. From all indications, coyotes were having negligible or no impact on these mule deer populations during the period studied.

The Sixteenmile Study Areas (Haw Gulch and Dry Canyon) included roughly half of the mule deer winter range in the Sixteenmile Basin. In terms of data collection these are referred to as the North and South Sixteenmile mule deer winter ranges, with the road from Maudlow through the Middle Fork Canyon (between Hatfield Mountain and Elkhorn Ridge, Figure 4) separating the two. Mule deer on these areas winter within an elevational range from just over 4,400 ft along Sixteenmile Creek near Maudlow to approximately 6,000 ft. Because of its generally southerly aspect, the North Sixteenmile winter range usually has a larger amount of snowfree area for a longer period of time, than does the South Sixteenmile winter range. Otherwise the two are similar, with generally slight to moderate relief, and extensive areas of shrubby and shrub-grass vegetation interspersed with varying amounts of tree cover as previously described. Due to the mixup in planned coyote control, hunting and trapping was done on the entire North Sixteenmile winter range. Therefore, mule deer classifications from the South Sixteenmile and other winter ranges in the Bridger Mountains are used as the check or unhunted area in comparing coyote control versus the lact of control. To better understand these comparisons, and since the major winter range areas vary widely in vegetational, climatic and land use characterisites, a brief description of each winter range area (Mackie et al. 1979) will be given here. Three separate winter range areas occur on westerly slopes of the Bridgers, and will be collectively discussed as West Slope winter ranges. These areas range in elevation from 5,200-5,600

Table 16. Results of mule deer classification flights on Miles City study areas from late winter 1975-76 through fall 1979. Fall flights were with a fixed-wing aircraft; winter flights with a helicopter.

	HOOK RANCH[1/]					FORT KEOGH				
	Adults			Fawn:100		Adults			Fawn:100	
	Male	Female	Fawn	Female	Adult	Male	Female	Fawn	Female	Adult
Late Winter 1975-76	52		17	-	33	44		20	-	46
Fall 1976	3	5	2	-	-	NONE OBSERVED				
Late Winter 1976-77	53		35	-	66	NOT FLOWN				
Fall 1977	13	20	16	80	48	2	7	6	86	67
Late Winter 1977-78	193		93	-	48	50		24	-	48
Fall 1978	2	16	19	119	106	1	1	2	-	-
Late Winter 1978-79	54		23	-	43	38		19	-	50
Fall 1979	1	3	6	-	-	1	13	15	115	107

1/ Coyote control was initiated on this area at the time of the late winter 1976-77 flight and terminated after the late winter 1977-78 flight.

ft at their lower limits up to 6,800-7,200 ft, and are characterized by steep open slopes dominated by grass-forb or grass-shrub vegetation. Moderate to dense timber, primarily Douglas-fir, is interspersed and extends upward along north slopes of canyons and draws from the lower limits of the winter ranges. Scattered timber and Rocky Mountain juniper usually extend onto south and west exposures at higher elevations.

Three winter range areas have also been recognized on the east side of the Bridgers and will likewise be discussed collectively. All occur on broad, open ridges and bench lands ranging in elevation from 4,800-5,200 ft at the lower limits of mule deer distribution to an upper limit of 6,000-6,200 ft in most years. East Side winter ranges have relatively open vegetation consisting of sagebrush-grassland with scattered individuals or clumps of Rocky Mountain juniper. Agricultural croplands are interspersed, especially at lower elevations, while timber cover generally occurs along a few drainages and at higher elevations. Mackie et al. (1979) provide greater detail on vegetational, climatic and other environmental characteristics of these winter ranges.

In general, the Sixteenmile and East Side winter ranges are more similar to one another in terrain, vegetation and deer population dynamics than either is to West Slope winter range areas. Winter severity on East Side winter ranges is somewhat intermediate between the West Slope (most severe) and Sixteenmile (least severe) areas.

Early and/or late winter results of mule deer helicopter classification flights from the North Sixteenmile winter range (coyote control area) are compared with those from the South Sixteenmile, West Slope and East Side winter ranges (where no formal coyote control was conducted) in Table 17. The thing most apparent from this data, and certainly the most important when considering the impact of coyote control on mule deer populations, is that the trend in fawn:adult ratios on all areas is the same between years. Fawn:adult ratios on all areas were only mediocre in winter 1974-75, declined the following year and then, with two minor exceptions, increased each year thereafter (Table 17). This suggests that a common factor was affecting the mule deer populations in all areas, and that coyote population levels were not the primary factor, and at least in some years may have been of little or no importance. In other years, however, coyotes may have been an important proximal cause of deer mortality, as will be discussed in detail later.

Winter severity, based on severity indices calculated from data for the MSU weather station in Bozeman (Mackie et al. 1980) cannot fully explain the trends noted. However, it does appear that some overwinter loss of fawns is normal in most areas in most if not all years. Although winter 1974-75 was the second most severe of the last 9 winters (1971-72 through 1979-80 , inclusive), no overwinter fawn mortality is indicated for the North Sixteenmile winter ranges. It is probable that fawn losses occurred following the late winter (late March) flight as was the case on the Armstrong winter range (West Slope) that winter. Fawn mortality on Armstrong's occurred in early to mid-winter with loss of old animals somewhat later, and prime-aged deer (2-7 years) succumbing after May 1 (Mackie et al. 1976). Verme and Ozoga (1971) have pointed out that extreme mid-winter severity, in itself, is not especially deadly for deer since they are physiologically "geared down" at this time. Physically devastating winters are those which subject animals to prolonged, unrelenting attrition. Assuming that North Sixteenmile winters are generally somewhat less severe than on Armstrong's (due to aspect and elevational differences) but that winter 1974-75 persisted longer than normal (deer remained on the Armstrong winter range several weeks longer than normal in spring 1975; Pac 1976), fawns, and possibly older animals as well, were very likely lost after March on the North Sixteenmile area.

The severe winter of 1974-75 apparently had a carryover affect on fawn survival the following year, probably acting through high fetal and early post-partum (within 48 hours) fawn mortality, as reported by Verme (1962, 1963) for does on winter and spring experimental diets of low nutritional value. In addition, Verme (1963) reports that although fawns that were light in weight at birth grew proportionally faster during their first four weeks of life than did heavy fawns, the final weight differential was still considerable. This could account for the reported relatively high fall-early winter 1975 fawn mortality on the Armstrong winter range (Pac 1976). Most of this loss apparently occurred during a week of heavy snowfall and sub-zero temperatures in late November. This could also explain both the low fawn:adult ratios found on all areas in early winter 1975-76, and the proportionally rather high overwinter fawn loss noted on some areas in this relatively mild winter (second mildest of the last 9).

Since some overwinter fawn loss appears normal and few fawns were preset at the start of winter 1975-76, the loss of a relatively small number would account for the large *percentage* loss noted, especially on the West Slope. Losses on the

Table 17. Results of mule deer helicopter classification flights on the North Sixteenmile winter range (coyote control area) and other winter ranges with no coyote control in the Bridger Mountains, winter 1974-75 through winter 1979-80.

Winter Range	YEAR AND SEASON											
	1974-75		1975-76		1976-77		1977-78[1/]		1978-79		1979-80	
	Early Winter	Late Winter	Early Winter	Late Winter	Early Winter	Late Winter	Early Winter	Late Winter	Early Winter	Late Winter	Early Winter	Late Winter
North Sixteenmile												
Number Classified	662	482	766	725	808	827	910	1,045	1,266	1,041	697	1,204
Fawns:100 Adults	33	33	22	10	40	26	62	39	67	48	76	66
Fawn Mortality (%)	0		54		35		37		28		13	
South Sixteenmile												
Number Classified	378	-	290	-	314	-	581	-	601	728	-	725
Fawns:100 Adults	23	-	19	-	47	-	62	-	59	47	-	71
Fawn Mortality (%)	-		-		-		-		20		-	
West Slope												
Number Classified	938	1,048	797	552	636	779	882	507	748	814	605	1,020
Fawns:100 Adults	35	18	15	9	35	33	42	32	67	38	53	47
Fawn Mortality (%)	49		40		6		24		43		11	
East Side												
Number Classified	599	-	906	-	81	-	1,632	-	2,189	2,001	579	2,110
Fawns:100 Adults	40	-	28	-	47	-	64	-	69	33	76	65
Fawn Mortality (%)	-		-		-		-		52		14	

1/ Coyote control was initiated on the North Sixteenmile area prior to the early winter flight in 1977-78 and continued through the late winter of 1978-79.

North Sixteenmile area also included some known coyote predation. The remains of deer killed by coyotes generally consisted of only patches of hide and hair plus the rumen contents and an occasional bone. This made them difficult to find and the sex and age could seldom be determined. Most of those that were checked appeared to be fawns, although a few adult losses were documented. Rough calculations, based on a number of factors (fawn:adult ratios, observed affects of the winter on deer, probable natural losses, coyote kills examined, prevalence of deer in the coyote diet, daily food requirements of coyotes, and others) suggest that perhaps 45-50 fawns and a small number of adult deer (10-12) may have been lost to coyotes in the roughly 3 month interval between early and late winter. Most of these would have survived to at least spring in the absence of predation. Conversely, some deer that would not have survived the winter were undoubtedly killed by coyotes, making the impact of predation appear even greater than it was. In fact, coyotes may be the proximal cause of most of the recorded mortality this winter although climatic factors were the underlying cause in many instances.

Although production and/or survival of fawns to early winter 1976-77 was not spectacular, this was the least severe of the last 9 winters, which is reflected in the low percentage of overwinter fawn loss on West Slope winter ranges (Table 17). Again, coyotes appear to have been responsible for the difference in overwinter fawn survival between West Slope and North Sixteenmile winter ranges. Rough calculations of direct predation losses for this winter are on the order of 70-75 fawns and perhaps 15-18 adults. Since this was a mild winter, the bulk of these would probably have survived in the absence of predation.

Winter 1977-78 was the first year since this study began that early winter fawn:adult ratios could be considered good (Table 17), suggesting increased survival of fawns from birth through fall on all areas. This was a winter of slightly less than average severity, and was also the year that coyote control was initiated on the North Sixteenmile areas. Nearly 75 percent of the coyotes removed were taken between the early and late winter flights, and any effects coyote control may have had on fawn:adult ratios prior to the early winter flight are therefore minimal. Since coyote control continued from late fall through mid- to late winter, the full effects of reduced coyote numbers on the deer population were not apparent this year, and some loss of deer to coyotes continued through most of the winter. Deer losses above what would have probably been normal for this winter were figured at roughly 55-60 fawns and on the order of 15 adults. This represents roughly half, or slightly less, of expected losses in the absence of coyote predation. As in other years, coyotes may have been the proximal cause of death of many deer that would not have survived the winter anyway, making the impact of predatory losses appear greater than they actually were.

Fawn:adult ratios for early winter 1978-79 again showed good fawn survival over the summer. However, this winter was the most severe of the last 9, resulting in relatively high overwinter fawn mortality on West Slope and East Side winter ranges, and moderate losses on Sixteenmile winter ranges. General observations indicated that snow melted off of Sixteenmile areas much earlier in spring than on West Slope areas, probably accounting for much of this difference. Also, although the winter severity index was considerably higher than for 1974-75, early spring growth and development of plants was about average, with somewhat faster than normal development later in the spring (Mackie et al. 1979). With this set of conditions, Sixteenmile areas would probably be much more normal in terms of winter severity than the rest of the

Bridgers. This probably accounts for much of the lowered fawn mortality on these areas. Losses on all areas would have been even greater had the winter dragged on into spring as was the case in 1974-75. This also shows that although they are of considerable value, winter severity indices by themselves do not adequately or precisely relate winter conditions to their effects on a species.

Coyote control continued on this area in 1978-79, with approximately half of the coyotes removed in late fall-early winter and the other half in late February. Any obvious effects of coyote control should have occurred in this year since coyote numbers were reduced, probably resulting in large part from the previous years control efforts, and since this years control effort largely occurred somewhat earlier. Although the coyote diet on North Sixteenmile included a high proportion of deer during this winter (see food habits section), it appears that the overwinter fawn loss was probably about normal under the prevailing conditions, and that the coyotes were either obtaining deer as carrion, or killing deer doomed to die anyway. Further evidence of this was the location of several deer carcasses in late winter and spring that had not been fed on by coyotes, something not noted in previous years.

The following winter (1979-80) again saw good early winter fawn:adult ratios. Overall winter conditions were only slightly less severe than average (Mackie et al. 1980), and overwinter fawn loss was similar, and relatively low, on all areas. This suggests another year of insignificant coyote predation on North Sixteenmile deer, despite the fact that coyote control had ceased, and coyotes may have killed some deer. Whether this indicates a change in coyote behavior or simply reflects reduced coyote numbers is not known.

Some generalizations can be made from the above:

1. Although coyotes reportedly had been killing deer on this area in previous years (indeed, this was part of the reason this area was selected for study), coyote predation on deer in winter 1974-75 appeared negligible;

2. Coyote predation during the winters of 1975-76 through 1977-78 did appear to reduce late winter fawn:adult ratios below what they probably would have been in the absence of predation;

3. Overwinter deer losses in 1978-79 and 1979-80 were about what would be expected for prevailing conditions, possibly in large part due to our control efforts, at least in 1978-79;

4. Coyotes were probably the proximal cause of death for a good share of the deer lost in most winters on this area, but in some years they were only keeping up with other mortality factors, primarily winter weather (1974-75 and 1979-80) and in 1978-79 they didn't even scavenge on many winter-killed deer.

5. This suggests that although coyotes may prey fairly heavily on deer in a given area, this is not a constant factor between years, and environmental factors seem to affect long-term deer population trends much more than predation.

If we assume that all of the deer killed by coyotes during winter (beyond other natural mortality) had survived to the following fall, their contribution to the hunter harvest can be approximated. Although weather during the hunting

season can greatly affect the harvest, Mackie et al. (1980) show that the annual harvest of deer marked on the Armstrong winter range during recent years was generally less than 5 percent, including years of more liberal hunting seasons than at present. If we figure generously, by assuming a 10 percent harvest level, only 6 additional deer would have been harvested on this area in 1976. If the remaining deer (54) had survived to the following hunting season (1977) they would have produced about 22 fawns to early winter (based on 40 fawns:100 adults in early winter 1976-77). These plus the 90 predation losses in the intervening winter could have resulted in about 17 additional deer harvested in 1977. Similar figures for 1978 and 1979 would have been 28 and 30 additional deer harvested, respectively. Since no winter predation losses were apparent in either 1978-79 or 1979-80, this would have been the maximum annual increase for this population during the years studied. Actual numbers would have been somewhat lower because some natural mortality of these deer would have occurred.

It is apparent, at least in this case, that an annual large scale coyote reduction program would not greatly benefit hunters in terms of deer in the bag. This is especially true in areas subject to periodic severe winters, where, at least in some instances, one bad year can essentially eliminate fawn recruitment for 2 years, and reduce deer levels to a lower point than would sustained, relatively heavy coyote predation.

Missouri River Breaks mule deer populations are reported in detail by Hamlin (1979, 1980b). To maintain consistency with the above mule deer discussions for other study areas, recent mule deer population trends which he reports are repeated here, as gleaned from his reports.

Results of early and late winter classification flights on Missouri Breaks study areas are shown in Table 18. The overall trends, and trends in over-winter fawn survival are similar on both areas, with major between-area differences in fawn survival noted in 1976-77 and 1977-78.

Mule deer declines associated with severe environmental conditions (drought and/or severe winters) occur at irregular but not infrequent intervals on this area, with recovery generally starting within a year or two. However, a decline that occurred in winter 1971-72, caused by severe winter conditions following a summer of poor forage production, continued to 1976-77. Recovery did not occur during this period despite the fact that normal growing season precipitation and mild, open winters were the general rule from 1972 to 1976. The apparent problem was low fawn production and/or survival, and ultimately, low fawn recruitment.

Hunting patterns (human) and deer population growth characteristics prior to the winter of 1971-72 had probably placed a substantial proportion of the female segment of the deer population in the vulnerable old age category. Therefore, the subsequent winter mortality, which approximated 85-90 percent for fawns and 30 percent for adults (an even higher proportion of females) resulted in a population age structure consisting almost entirely of prime age animals. Low fawn survival in subsequent years resulted in virtually no biological surplus, and therefore hunting mortality was directed primarily toward prime age, producing adults. A year of heavy hunting pressure (2 deer-either sex) and high harvest, and 2 subsequent years of 1 deer-either sex seasons followed the severe winter, aggrevating the population decline it had precipitated. After 1974, hunting ceased to be a mortality factor for females and fawns, and adequate forage and mild winters prevailed, yet overall fawn survival remained low and the population failed to increase.

Table 18. Results of aerial classifications of mule deer on Missouri Breaks Study Areas, winter 1975-76 through 1979-80, (after Hamlin 1980b).

Study Area	YEAR AND SEASON									
	1975-76		1976-77		1977-78		1978-79[1/]		1979-80[1/]	
	Early Winter	Late Winter	Early Winter	Late Winter	Early Winter	Late Winter	Early Winter	Late Winter	Early Winter	Late Winter
Nichols Coulee										
Number Classified	208	115	88	118	122	76	160	192	263	282
Fawns:100 Adults	21	5.5	40	28	36	12	50	40	80	77
Fawn Mortality (%)	74		30		67		20		4	
Wilder Trail										
Number Classified	323	193	258	293	322	255	501	409	680	683
Fawns:100 Adults	37	11	34	30	44	26	80	65	91	82
Fawn Mortality (%)	70		12		41		19		10	

[1/] Data on the Nichols Coulee Study Areas in these two years was obtained with a fixed wing aircraft and are not directly comparable to other flights.

Knowles (1976) documented high winter loss of deer to coyotes on this area in 1975-76, and although its magnitude has declined to relatively low but stable numbers in 1977-78 through 1979-80, predation has been the proximal cause of most documented overwinter mule deer mortality. Hamlin (1979) and Pyrah's (1980) report on coyote populations discuss the impact of coyotes on deer in the Missouri Breaks during winter, and this will not be repeated here. Previous discussion of mule deer covered this for the other areas also.

Summer fawn mortality on the Wilder Trail area (see the next section for more details) indicated overall fawn losses of 36, 32, 13 and 14 percent for summer 1976 through 1979, respectively. Coyote predation accounted for a minimum of 73 percent of this mortality, and was the greatest proximal cause of summer mortality, even in years of low mortality. Overall fawn survival rates during this period (1976-79) appear to have been closely and positively correlated with population levels of small mammals (see food habits and small mammals sections), but not with coyote densities which are detailed by Pyrah (1980).

Fawn Telemetry - Studies of early neonatal mule deer fawn mortality with emphasis on causes, timing and extent of such losses, especially as they relate to coyote predation, are being conducted on the Wilder Trail Study Area. These studies were initiated in 1976 and will continue through at least 1980, and are utilizing radio telemetry to assist in determining survival and to hopefully find any mortalities before cause of death is obliterated. The latter is not always possible however. The number of fawns monitored (including members of a set of twins that were not radio marked) during the summers of 1976 through 1979 totalled 11, 19, 16 and 22. One fawn was abandoned shortly after marking in each of the latter two years, and since they probably resulted from handling they are not included in the tabulation of results in Table 19. Coyotes were the definite or probable cause of death for 73 percent of the fawn mortalities noted over the 4 summers, and 17 percent of all monitored fawns were in this category. No fawns exhibited signs of poor condition prior to death. The lowered incidence of coyote caused fawn mortality noted in 1978 and 1979 coincided with increased small mammal populations. Small mammals may have been responding to forage conditions which included poor production but fall greenup in 1977, good production in 1978 with extensive first year sweetclover, and extensive sweetclover in 1979 which, however, dried up by August (Hamlin 1979). Dood (1978) felt that factors which reduce the cover required by fawns on this area would probably increase their vulnerability to predation, and therefore the abundance of sweetclover may have been doubly important by also providing higher security fawn bedding cover, especially in 1979.

A number of recent fawn mortality studies similar to ours which have utilized telemetry have been reported (Carroll and Brown 1977, Davis et al. 1976, Anderson 1976, Stiver 1978, Garner et al. 1976, Trainer 1975, Cook et al. 1971, Steigers and Flinders 1980, and others). Although these studies differed in many respects and are therefore not strictly comparable, they are valuable in that they show a wide range of conditions and cover a variety of areas and include both mule deer and whitetails. Several of these studies show relatively high overall losses, with coyotes often being the cause of a large percentage of the total mortality. The overall observed mortality rate from our studies can best be described as moderate when compared to these other studies. An interesting fact to emerge from examining this series of studies

Table 19. Causes and extent of mule deer fawn mortality on the Wilder Trail Study Area for the summers of 1976-1979. Data for 1976 and 1977 are from Dood (1978) and for 1978 and 1979 are from S. Riley (pers. comm.).

	Number of fawns		Number of deaths caused by			Mortality attributable to coyotes	
Summer	Monitored	Died	Coyotes	Accident	Unknown	As a % of All Mortalities	As a % of all Monitored Fawns
1976	11	4	4	-	-	100	36
1977	19	6	4	1	1	67	21
1978	15[1]	2	1	-	1	50	7
1979	21[1]	3	2	-	1	67	10
TOTAL	66	15	11	1	3	73	17

[1]Does not include 1 fawn abandoned shortly after handling.

is that the areas having the highest percent of radioed fawns killed by coyotes were also areas entirely or mostly closed to hunting (Cook et al. 1971, Garner et al. 1976). Cook et al. (1971) felt that coyotes played a major role in maintaining a stable relationship between a high population of whitetails and their food supply. Areas apparently open to hunting had lower percentages of the total fawn sample killed by coyotes, and an area about 50 percent accessible to public use, including hunting, had an intermediate percentage of all radioed fawns taken by coyotes (Steigers and Flinders 1980). Certainly other factors are involved here (for example, areas open to hunting of deer are probably also open to coyote hunting), but this would suggest that a good share of coyote predation on young fawns may be compensatory in nature. Whether this apparent relationship would hold up to close scrutiny in unknown and is beyond the scope of this report.

Some general comments on the impact of predation on ungulates appears in order here. As Connolly (1978b) has pointed out, a sufficiently selective literature review can reinforce any desired view on the subject of predation in regards to big game animals. His paper presents a recent comprehensive review, pointing out many studies in which either numbers or growth rates of ungulate populations were thought to be limited by predation, as well as many others which came to the opposite conclusion. Since Connolly (1978b) covers this quite well it will not be repeated here, and interested readers are referred to his paper. Connolly (1978b) further states that it is overly simplistic and pointless to try to account for all ungulate irruptions in terms of any single cause (such as removal of predators). The same could be said of ungulate declines as well, or the impact of the 1972 ban on the use of toxicants on Federal lands.

The view that death from predation was largely compensatory in nature (Errington 1946 and other earlier works) dominated the thinking on the effects of predation

for years, yet Errington recognized that intercompensation was less complete in ungulates. He also saw more reason for believing that predation, especially by canids, could have a truly significant influence on population levels of at least some wild ungulates, and gave some examples (Errington 1946). For some reason Errington's thinking regarding the effects of predation, gained from his studies of bobwhite quail (*Colinus virginianus*) and muskrats (*Ondatra zibethicus*), was widely accepted and almost universally applied to all predator-prey interactions. However, his somewhat precautionary note concerning ungulates and their predators, especially canids, was similarly almost universally ignored.

Keith (1974) also reviewed the literature relevant to predation on ungulates and concluded by endorsing the view of Pimlott (1967) (although not original with him, and probably a rather ancient view) that the absence of self-regulating mechanisms among ungulates is good *prima-facie* evidence that pristine populations were exposed to effective predation. Such predation apparently kept ungulate numbers below levels where in intraspecific competition would lead to selection for strategies to limit populations. It should probably be noted that wolves formerly occupied most of North America (Young and Goldman 1944) and were probably the primary predator involved. In his review of predation on ungulates Keith (1974) found that the inconsistencies between studies reporting that predators affect ungulates and those stating they had no effect, largely stems from differences between ungulates in highly modified (usually by man) versus more natural environments. In cases where adequate hunting pressure is absent, North American ungulates in highly modified environments typically irrupt to levels where recurrent critical interactions with food supplies constitute the dominant mechanism of population reduction. He felt that natural enemies could seldom if ever reduce such irruptive populations. In regards to both this and the almost universal application of Errington's work with quail and muskrats to ungulates, some comments of Pimlott (1967) are particularly relevant. He states that since environmental changes or disturbances have favored ungulates (deer and moose in his example), and their populations are probably higher than they have ever been, contemporary biologist often have a distorted viewpoint about ungulate-predator interrelationships. Naturally, under such circumstances it is not much wonder that we have been inclined to argue that predators do not act as important limiting factors on deer and moose. The same would be true of other predator-ungulate interrelationships as well.

If we can speculate that deer habitats at present are more toward the pristine end of the disturbance spectrum than say 20-40 years ago (through advancing forest succession and less disturbance due to factors such as grazing, etc.), we could be witnessing a shift in the impacts of predation on deer (from little or no impact to increasing impact). It would seem logical that if this shift is occurring, at some point predator control would be suggested as a solution to the apparent problem. However, predator control to benefit ungulates is probably not economically justified in any but the more intensively managed areas, and even here it might be questionable. Even where it might be justified, the admonition of Knowlton (1968) that "intensive management" carries with it the implication of full harvest must not be lost sight of. Such predator control efforts (to benefit other wildlife) can be justified on no other basis, and as Knowlton (1968) further points out, if we don't intend to fully utilize the crop that is available, there is no reason to deny it to the carnivores. It is doubtful that there are many (any?) areas in the state that would provide sizable increased deer harvests following intensive predator control strictly for this purpose.

SMALL MAMMALS

Leporids - Numbers of cottontails and jackrabbits observed on Missouri Breaks study areas are shown in Table 20. Jackrabbits increased on all Missouri Breaks routes in 1979 over the previous year. They were the highest recorded over the last 4 years on the Wilder Trail area, and second highest on the Nichols Coulee area. Cottontail numbers increased in the breaks type on the Wilder Trail area for the second straight year, however, none were seen on the prairie route on this study area, and only 1 was seen on the Nichols Coulee area. Although leporids appeared to be at higher levels on both Missouri Breaks areas in 1979 than the previous year, this was not reflected in the coyote diet, probably because of the glut of mice available.

As pointed out in the methods section, leporid census techniques were unuseable on Sixteenmile areas and abandoned after a brief trial. No new data on leporid numbers were obtained from Miles City areas beyond what was presented and discussed in previous reports (see Schladweiler and Pyrah 1979a, 1979b, for details).

Although fluctuations of coyote numbers in response to lagomorph population changes have been reported (for instance Clark 1972) with one possible exception (see below), this does not seem to have occurred on any of our study areas over the course of the study. This does not mean that it wouldn't occur, especially if the study covered a long enough time period. The general discussion concerning small mammals will treat this more fully.

Rodents - As with leporids, no new data were obtained on rodent populations on Miles City areas in 1979 and readers are again referred to a prior report (Schladweiler and Pyrah 1979b) where this data is presented and discussed.

Indices to *Peromyscus* (the primary small mammal present) abundance on Sixteenmile areas are given in Table 21. This data appears only vaguely related to the percentage of rodents in the coyote diet on these same areas (Table 11). *Peromyscus* levels also do not show any apparent depression due to coyotes, since they were at their highest level at the beginning of the study, when coyotes also appeared most abundant, and declined to their lowest levels in the two years following intensive coyote removal. Whether the *Peromyscus* population influenced coyote numbers on these areas in unclear since both were fairly high at the start of the study and our control efforts reduced coyote numbers before any possible affects of declining *Peromyscus* numbers would have been apparent. Whether the high populations of both at the start of the study were related will have to remain unanswered.

Small mammal trapping data from 1976-79 for Missouri Breaks areas was summarized and graphically presented by Hamlin (1979). This data showed similar trends for both areas, and so they will be discussed together. Much of the 1976 and 1977 data are from Trout (1978), and anyone wanting additional details can consult his work and that of Hamlin (1979). The figures show that *Peromyscus* levels were fairly low in both 1976 and 1977, with little apparent difference in population levels between these years. Microtine levels were very low on these areas during 1976 and 1977 as well. Populations of *Peromyscus* increased tremendously in 1978 and apparently peaked in the fall or early winter. Microtines showed up consistently for the first time as well during 1978, but population levels were not large. Populations of *Peromyscus* declined in 1979 but were still generally above levels noted in 1976 and 1977, while microtines increased considerably over the previous year. Species composition of microtines

Table 20. Results of headlight surveys conducted on Missouri Breaks study areas, 1976-1979, expressed as number observed per 100 miles of routes.

Species	Area, General Vegetation Type, Year and Miles of Route Covered											
	WILDER TRAIL[1]								NICHOLS COULEE			
	Breaks Type				Prairie Type				Breaks Type			
	1976 (300)	1977 (400)	1978 (297)	1979 (301)	1976 (528)	1977 (330)	1978 (264)	1979 (264)	1976 (205)	1977 (231)	1978 (234)	1979 (234)
Jackrabbit	3.3	10.0	9.4	37.9	37.9[2]	33.6	57.6	71.6	14.1	54.5	17.5	39.3
Cottontail	4.3	6.0	1.3	3.7		1.5	0.0	0.0	4.9	8.2	1.3	0.4

[1]Data from Trout (1978) combined with additional data collected by project personnel from the same routes, therefore doesn't agree with Trout (1978).

[2]Cottontails and jackrabbits combined, but primarily the latter.

Table 21. Captures of *Peromyscus* per 100 trap nights on Sixteenmile study areas, 1975-79.

Trapline No.	1975	1976			1977			1978			1979		
	Fall	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall
HAW GULCH													
1	16.8	-	-	37.6	-	-	23.1	-	-	6.4	-	-	5.4
2*	47.2	11.1	20.1	43.2	4.1	12.5	10.5	0.6	0	2.9	-	0	0.6
3*	56.3	50.0	48.2	49.1	18.8	31.8	38.7	3.1	10.2	13.3	-	12.5	18.0
4	31.2	-	-	21.2	-	-	17.4	-	-	9.0	-	-	8.7
5	6.9	-	-	12.9	-	-	0	-	-	0	-	-	0
6	-	16.5	-	-	9.1	-	-	6.3	-	-	-	-	-
7	-	11.1	-	-	2.4	-	-	0.7	-	-	-	-	-
8	-	12.1	-	-	1.2	-	-	0	-	-	-	-	-
9	-	-	16.2	-	-	10.0	-	-	5.9	-	-	3.4	-
10	-	-	26.0	-	-	11.1	-	-	0.6	-	-	4.2	-
11	-	-	4.0	-	-	0	-	-	0	-	-	0	-
Combined	34.5	23.0	25.3	35.9	7.8	14.9	20.1	2.2	3.8	7.1	-	4.9	7.4
DRY CANYON													
1	19.0	-	-	26.2	-	-	11.3	-	-	14.2	-	-	7.1
2*	65.3	39.9	62.7	89.8	28.2	47.3	31.5	10.5	14.9	11.4	-	10.4	39.0
3	17.3	-	-	15.0	-	-	5.5	-	-	0.6	-	-	0.7
4	13.9	-	-	6.2	-	-	1.2	-	-	0	-	-	0
5*	20.0	11.5	26.1	40.3	3.1	14.2	20.2	0	2.4	5.6	-	5.7	4.1
6	-	1.7	-	-	0	-	-	5.1	-	-	-	-	-
7	-	2.8	-	-	0.6	-	-	0	-	-	-	-	-
8	-	15.4	-	-	1.2	-	-	0	-	-	-	-	-
9	-	-	5.9	-	-	5.5	-	-	6.0	-	-	1.2	-
10	-	-	11.3	-	-	1.3	-	-	1.8	-	-	1.2	-
11	-	-	71.4	-	-	0	-	-	0	-	-	1.5	-
Combined	28.8	15.6	27.4	37.9	7.4	15.3	15.6	3.8	5.6	6.9	-	4.2	11.7

*Live trap lines run each time, others are snap trap lines run once per year, but always at the same season.

differed between 1978 and 1979, with sagebrush voles (*Lagurus curtatus*) being much more abundant in the second year. Although microtine numbers were up considerably in 1979 over the previous year, this increase was not great enough to offset the decline in *Peromyscus*, and the overall 1979 catch rates for both combined were intermediate between 1978 and the 2 years prior to that. Coyotes responded to this large increase in rodent numbers by feeding heavily on them, beginning in fall 1978, especially on the Wilder Trail Study Area (Tables 12-13). No food habits samples were obtained from the Nichols Coulee Study Area after fall 1978, and rodents did not increase in the coyote diet on this area at that time. This is probably related to two factors, an apparent abundance of rose hips on this area in fall 1978, and the fact that although the rodent increase on this area was as large proportionally as on the Wilder Trail area, numerically they were not as abundant.

Pyrah (1980) noted that coyote population levels during these same years (1976-79) were relatively stable. Coyote numbers declined between 1976 and 1977, then increased the following 2 years, apparently in response to the increased rodent numbers. The 1979 coyote population was about the same as that of 1976, and although good data are lacking, indications are that coyotes were more abundant in 1974 and 1975 than during the course of this study. Possible reasons for this will not be speculated on here.

Solomon (1949) has characterized the response of predators to changing prey densities as either functional (prey taken per predator per unit time varying directly with prey density) or numerical (changes in predator density). The latter should not be an immediate response in the coyote since a large influx of coyotes into an area of abundant prey would not be expected. A numerical response would have to operate through a functional response, since coyote population changes would be expected through changes in survival and reproductive rate.

Unless rodent populations in the Missouri Breaks started to increase in the fall of 1977 (which our data would not show), the increased litter size and larger number of coyote pups produced in 1978 cannot be attributed to increased rodent numbers. They more likely resulted from increased numbers of leporids, especially jackrabbits, in 1977 compared to 1976. Besides increasing overall, jackrabbit numbers in 1977 continued increasing from spring through fall, whereas in 1976 observed numbers steadily declined after July (see Hamlin 1979).

In his paper on population dynamics Keith (1974) reviewed the literature regarding the role of predators in population fluctuations of both lagomorphs and microtines, concluding that there were many common traits among the two. Without going into the literature further, these conclusions will be presented here based on his review. It should also be noted here that usually a wide variety of predators are involved, not just a single species such as the coyote.

Predators appear incapable of preventing a population increase in prey when conditions are right for such an increase. Similarly, some factor other than predation must intervene and reduce prey below peak abundance before predators can excercise any control. During the prey decline, predation is inversely density dependant and persists as a dominant and depressive form of mortality for some time after prey populations reach their low. Thus, predation increases the amplitude of prey fluctuations by reducing their numbers during the population low below what would normally occur, and also lengthens the interval between peaks by prolonging the duration of the lows. Prey populations eventually escape this control, either through reduced predator population levels or their

switching to another more numerous food, and thus the stage is set for another prey increase. In this manner predation may synchronize prey fluctuations locally or regionally depending on the mobility of the predator populations involved.

RECOMMENDATIONS

The results of this study show that factors such as winter severity have a greater long term impact on deer and antelope populations than do predators. Furthermore, there are few if any areas in which management of deer or antelope is intensive enough to justify the control of predators for the sole benefit of these species. Thus, unless conditions change, either through more intensive utilization of the big game resource, or more drastic predation on these species, predator control solely to benefit big game cannot be justified nor recommended. In fact, it is recommended that no predator control activities be engaged in by this Department solely to benefit populations of any game species.

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APPENDIX A

APPENDIX A

Vegetation of Hook Ranch and Ft. Keogh Study Areas.

Procedures: Tentative cover types of the areas were determined by reconnaissance and observation in a manner similar to that reported by Jorgensen (1974).

Once tentative cover types were determined, representative stands within each type were selected and canopy coverages sampled using a modification of the method described by Daubenmire (1959) which uses seven canopy coverage classes rather than six. Quadrat placement was random along a line within the stand, and 20 quadrats in each stand were normally sampled. In all, 23 stands were sampled to provide vegetal descriptions of the types; species lists only were made in 3 habitat types. Additional canopy coverage measurements of shrubs were made utilizing line intercept (Canfield 1941) along two, 100 foot lines, one at the beginning and one at the end of each of the 10 small mammal traplines on each area. Height of each shrub intercepted was also recorded. All data were gathered during August and September of 1975.

Results and Discussion: This is only a description of the cover types found on the area, with no attempt being made to map or determine the areal extent of any type. Vegetation is similar on both areas although some types are present on one and not the other. The proportions of major types also differ between areas. Both areas show evidence of past and present heavy livestock grazing so that potential vegetation probably differs considerably from what currently exists. In addition, large areas of rangeland were converted to cropland on the Hook Ranch area in 1974 and 1975, and more is planned in future years.

Appendix Table 1 lists the cover types, the numbers of stands sampled in each, and the type of site where each can be expected to occur.

Appendix Table 1. Cover types of Hook Ranch and Ft. Keogh study areas, approximately in order from wettest to driest.

Cover Type	# Stands Sampled	Site Remarks
1. SAAM-SCAM[1]	0[2]	Marsh, sides of reservoirs
2. PODE-SAEX	0[2]	Along rivers
3. AGSM-STVI	2	Gentle swales
4. ARCA-AGSM	2	Silty bottomlands with moderately high water tables
5. ARTR-SAVE-ARCA	3	Terrace level above bottomland terrace
6. AGSM-SAVE	1	Rolling uplands with perched water tables
7. AGSM-ARTR	4	Upland gentle footslopes, relatively flat and level
8. AGSM	2	Former and present prairie dog towns
9. CALO-STCO	2	Gentle slopes and ridges with very sandy soils
10. AGSP-ARTR	3	Rocky hilltops
11. ARTR-ATCO-AGSP	4	Steep, unstable, rocky slopes
12. ATAR-ATCO-SAVE	0[2]	Bentonite slopes

1/ See Appendix Table 3 for meanings of symbols

2/ No stands sampled, species lists only

Separations between some of the above types are sharp and obvious whereas other separations are very indistinct; so much so that types 3, 4, 6 and 7 probably represent a continuum. These types are all dominated by western wheatgrass (*Agropyron smithii*) and various proportions of different shrubs.

Appendix Table 2 lists cover types and average canopy coverage of all species in each type (combined data from all stands in each type).

Species samples and names appear in Appendix Table 3.

Appendix Table 2. Canopy coverage data from each cover type - Hook Ranch and Ft. Keogh study areas.

	COVER TYPE (See Table 3 for meaning of symbols)											
Species	SAAM[1] SCAM	PODE[1] SAEX	AGSM STVI	ARCA AGSM	ARTR ARCA SAVE	AGSM SAVE	AGSM ARTR	AGSM	CALO STCO	AGSP ARTR	ARTR ATCO AGSP	ATAR[1] ATCO SAVE
Graminoids												
Spartina pectinata	+	+										
Poa pratensis		+										
Carex spp.		+										
Elymus canadensis		+										
Hordeum jubatum	+											
Stipa viridula			T[2]		2						T	
Agropyron smithii			61[3]	30	32	43	31	48	4	8	5	
Poa secunda			30	T		t					T	
Carex elecocharis			42						1			
Distichlis stricta				T			T					
Koeleria cristata					2		1				2	
Bouteloua gracilis			3	15	26	7	30	7	10	2	12	
Buchloe dactyloides					8	7	3	11				
Carex filifolia					2		T		6		1	
Andropogon scoparius									2			
Calamovilfa longifolia				8					22			
Stipa comata			5	8	2	4	2		25	1	T	
Oryzopsis hymenoides											2	+
Agropyron spicatum										9	8	
Agropyron dasystachyum												+
Shrubs												
Salix exigua	+	+										
Symphoricarpus occidentalis		+										
Rhus radicans		+										
Artemisia cana				18	3				t		t	
Sarcobatus vermiculatus					3	4					3	+
Artemisia tridentata			9		2		8			11	5	
Atriplex confertifolia											4	+
Yucca glauca									3			
Atriplex nuttallii												+
A. argentea												+
A. dioica											+	+
Chrysothamnus viscidiflorus												+
Rosa arkansana												+

Table 2 (cont'd.)

Species	SAAM SCAM	PODE SAEX	AGSM STVI	ARCA AGSM	ARTR ARCA SAVE	AGSM SAVE	AGSM ARTR	AGSM	CALO STCO	AGSP ARTR	ARTR ATCO AGSP	ATAR ATCO SAVE
						COVER TYPE (See Table 3 for meaning of symbols)						
Sub-shrubs												
Eriogonum multiceps												
Gutierrezia sarothrae				T						T	T	
Artemisia frigida			3	2	6	2	T		1	2		
Eurotia lanata							T					
Opuntia polyacantha			1	T	3	1		2			T	
Forbs												
Xanthium strumarium	+	+										
Rumex mexicana	+	+										
Lactuca serriola	+	+										
Aster brachyactis	+	+										
Sonchus asper	+											
Cirsium arvense	+											
Glycyrrhiza lepidota	+	+										
Trifolium agrarium		+										
Taraxacum officinale		+										
Asparagus officinale		+										
Apocynum medium		+										
Ambrosia psilostachya		+										
Artemisia ludoviciana		+										
Helianthus laetiflorus		+										
Aster oblongifolius		+										
Helianthus annuus		+										
Chenopodium hybridum		+										
Euphorbia marginata		+										
Ratibida columnifera		+										
Cleome serrulata		+										
Asclepias speciosa		+										
Tragopogon dubius					1	3	T	1			T	
Plantago purshii			T	T	T	4	T	T	T	T	1	
Hedeoma hispida			T	T	T	T	T	T	T	T	T	
Vicia americana			2	T		T					T	
Linum rigidum			T	T			T	T	T			
Euphorbia glyptosperma							T			T	T	
Sphaeralcea coccinea			T	T	1		T	T	T	T	T	
Phlox hoodii			4		T		T			5	T	
Grindelia squarrosa												+
Aster tanacetifolia												+

Table 2 (cont'd.)

Species	COVER TYPE (See Table 3 for meaning of symbols)											
	SAAM SCAM	PODE SAEX	AGSM STVI	ARCA AGSM	ARTR ARCA SAVE	AGSM SAVE	AGSM ARTR	AGSM	CALO STCO	AGSP ARTR	ARTR ATCO AGSP	ATAR ATCO SAVE
Trees												
Populus deltoides	+	+										
Salix amygdaloides	+	+										
Rushes, sedges, etc.												
Scirpus americanus												
Typha latifolia												
Equisetum arvense												
Total # of species	13	36	24	24	26	24	32	13	35	19	37	14
# Grass species	1	9	8	7	9	7	12	6	10	5	11	3
# Shrub species	1	2	1	2	3	1	1	0	2	1	4	8
# Perennial forbs	5	15	7	7	6	7	7	1	14	6	10	2
# Annual forbs	2	4	6	4	2	3	5	3	6	4	4	1
Bare ground	NM[4]	NM	8	21	10	10	21	10	17	49	50	NM
Total vegetation	NM	NM	75	68	76	66	61	74	66	40	44	NM
Litter	NM	NM	52	42	27	71	25	58	38	22	21	NM

1/ Species list only, no quantitative data taken. A + indicates presence in that type.

2/ T = <1%

3/ Canopy coverage (percent)

4/ NM = not measured

Appendix Table 3. Species symbols and names.

SAAM - *Salix amygdaloides* - peachleaf willow

SCAM - *Scirpus americana* - american bulrush

PODE - *Populus deltoides* - eastern cottonwood

SAEX - *Salix exigua* - slender willow

AGSM - *Agropyron smithii* - western wheatgrass

STVI - *Stipa viridula* - green needlegrass

ARCA - *Artemisia cana* - silver sagebrush

ARTR - *Artemisia tridentata* - big sagebrush

SAVE - *Sarcobatus vermiculatus* - black greasewood

CALO - *Calamovilfa longifolia* - prairie sandseed

STCO - *Stipa comata* - needleandthread

ATCO - *Atriplex confertifolia* - shadscale saltbush

AGSP - *Agropyron spicatum* - bluebunch wheatgrass

ATAR - *Atriplex argentea* - silver saltbush

Appendix Tables 4 and 5 show the average canopy coverage and heights of shrubs along each of the 10 small mammal traplines on the Hook Ranch and Ft. Keogh areas, respectively. Big sagebrush (*Artemisia tridentata*) was the most common shrub on both areas, althoug silver sagebrush (*Artemisia cana*) and black greasewood (*Sarcobatus vermiculatus*) were locally important, especially on the Ft. Keogh area.

Appendix Table 4. Average canopy coverage and average height (both in feet) of shrubs measured along 200 feet of line on each of 10 small mammal traplines, Hook Ranch study area, 1975.

Trapline Number	Shrub Species							
	Artemisia tridentata				*Artemisia cana*			
	Live		Decadent		Live		Decadent	
	Average Percent Canopy Coverage	Average Height & Range In Heights	Average Percent Canopy Coverage	Average Height & Range In Heights	Average Percent Canopy Coverage	Average Height & Range In Heights	Average Percent Canopy Coverage	Average Height & Range In Heights
1	16.0	1.0(0.4-2.3)	1.7	0.8(0.4-1.2)	-	-	-	-
2	16.5	1.1(0.5-2.4)	2.8	1.0(0.5-1.5)	-	-	-	-
3	24.2	0.9(0.3-2.1)	1.2	1.0 (-)	-	-	-	-
4	9.8	0.6(0.2-1.4)	-	-	3.7	1.1(0.9-1.2)	-	-
5	26.6	1.0(0.4-2.0)	-	-	-	-	-	-
6	25.7	0.8(0.3-2.2)	4.0	0.8(0.6-1.3)	-	-	-	-
7	21.3	0.9(0.2-1.5)	2.4	0.8(0.4-1.0)	-	-	-	-
8	8.0	0.6(0.3-0.9)	0.7	0.6 (-)	-	-	-	-
9	20.6	1.2(0.3-2.0)	0.8	1.6(1.3-1.9)	-	-	-	-
10	24.6	1.3(0.4-2.2)	1.7	1.2(1.0-1.3)	-	-	-	-

Appendix Table 5. Average canopy coverage and average height (both in feet) of shrubs measured along 200 feet of line on each of 10 small mammal traplines, Ft. Keogh study area, 1975.

Trapline Number	Shrub Species											
	Artemisia tridentata				*Artemisia cana*				*Sarcobatus vermiculatue*			
	Live		Decadent		Live		Decadent		Live		Decadent	
	Average Percent Canopy Coverage	Average Height & Range In Heights	Average Percent Canopy Coverage	Average Height & Range In Heights	Average Percent Canopy Coverage	Average Height & Range In Heights	Average Percent Canopy Coverage	Average Height & Range In Heights	Average Percent Canopy Coverage	Average Height & Range In Heights	Average Percent Canopy Coverage	Average Height & Range In Heights
1	10.7	0.7(0.2-1.3)	0.9	0.8(0.7-0.8)	-	-	-	-	0.8	0.8(0.7-0.8)	-	-
2	3.0	1.4(1.1-1.8)	-	-	6.7	2.0(1.5-2.5)	-	-	1.4	2.0 (-)	-	-
3	6.6	1.2(0.7-1.7)	0.9	1.2 (-)	-	-	-	-	2.5	2.0(1.7-2.3)	-	-
4	10.2	1.6(0.9-2.8)	-	-	0.7	1.4 (-)	-	-	0.8	1.2 (-)	-	-
5	18.4	2.0(1.3-2.6)	-	-	-	-	-	-	-	-	-	-
6	10.6	1.8(1.0-2.2)	-	-	3.6	1.1(0.2-1.7)	-	-	1.6	3.0 (-)	-	-
7	6.8	1.2(0.8-2.1)	-	-	1.4	2.1 (-)	-	-	2.8	1.1(0.5-2.3)	-	-
8	16.0	1.4(0.8-2.1)	-	-	1.6	1.5 (-)	-	-	-	-	-	-
9	20.4	1.2(0.4-1.9)	-	-	10.1	1.6(1.1-2.9)	-	-	-	-	-	-
10	12.7	1.2(0.4-1.6)	-	-	-	-	-	-	2.0	1.7(1.3-2.1)	-	-

APPENDIX B

Appendix Table 6. Contents of Coyote Stomachs from various parts of Montana, Winter 1974-75. Figures are percent frequency of occurrence/percent of total diet. Presence of individual items in county samples are indicated by * but are not enumerated due to the small samples from most counties.

		County, and Number of Stomachs containing food							
	TOTAL (208)	Dawson (67)	Musselshell (64)	Yellowstone (8)	Petroleum (13)	Fergus (25)	Golden Valley (10)	Rosebud (12)	Ravalli (9)
RODENTS	52.4/27.5	46.3/25.8	56.2/26.7	87.5/31.2	23.1/11.5	84.0/50.2	50.0/24.7	83.3/33.2	22.2/ 0.1
Deer Mouse	27.4/11.7	*	*	*	*	*	*	*	
Meadow Vole	18.8/10.2	*	*	*	*	*		*	
Prairie Dog	2.4/ 1.9	*	*					*	
Pocket Gopher	1.9/ 1.4	*	*						
Kangaroo Rat	1.4/ 0.8		*						
Porcupine	2.4/ 0.7	*		*		*	*		*
House Mouse	0.9/ 0.5		*						
Wood Rat	0.5/ 0.1		*						
Unidentified Mouse	1.4/ Tr					*		*	*
Sagebrush Vole	0.5/ Tr							*	
RABBITS	26.9/14.7	19.4/ 9.6	31.3/18.3	12.5/ 0.6	38.5/30.4	32.0/14.5	20.0/ 7.0	50.0/32.7	---------
Cottontail	18.8/10.2	*	*	*	*	*	*	*	
Jackrabbit	6.2/ 4.2	*	*		*	*	*	*	
Snowshoe Hare	0.5/ 0.2					*			
Unidentified	1.4/ Tr					*		*	
OTHER MAMMALS	10.6/ 6.7	6.7/ 5.7	10.2/ 7.9	12.5/ 3.4	23.1/11.6	8.0/ Tr	20.0/11.5	8.3/ 8.1	11.1/11.1
Mule Deer	4.8/ 3.0	*	*	*		*		*	
Domestic Sheep	3.4/ 2.4	*	*		*		*		
Cattle (Calf)	0.5/ 0.5								*
Skunk	1.0/ 0.3		*		*				
Antelope	0.5/ 0.3						*		
Shrew	0.5/ Tr				*				
BIRDS	8.6/ 2.8	9.0/ 2.9	4.7/ 2.4	25.0/11.9	23.1/11.2	12.0 / Tr	---------	---------	22.2/ 0.7
Unidentified Passerine	2.9/ 1.1	*	*		*				
Domestic Chicken	1.4/ 0.7	*		*					
Sage Grouse	1.0/ 0.5				*				
Pheasant	0.5/ 0.5		*						
Unidentified	1.9/ Tr		*			*			
Magpie	1.0/ Tr								*
Unidentified Galliform	0.5/ Tr			*					
CARRION[1]	36.5/22.7	41.0/24.9	19.5/13.8	25.0/22.5	38.5/23.2	52.0/22.5	30.0/26.5	41.7/ 9.2	88.9/80.1
Cattle	20.7/14.2	*	*	*	*	*		*	*
Mule Deer	8.2/ 4.2	*	*	*	*			*	
Domestic Sheep	2.4/ 1.8	*	*						
Antelope	1.4/ 1.3						*		
Pheasant	1.4/ 0.8	*				*			
Sage Grouse	0.5/ 0.2					*			
Duck	0.5/ 0.1					*			
Muskrat	0.5/ Tr					*			
Unidentified Hawk	0.5/ Tr							*	
Horse	0.5/ Tr					*			

Appendix Table 6. Continued.

	TOTAL (208)	County, and Number of Stomachs containing food: Dawson (67)	Musselshell (64)	Yellowstone (8)	Petroleum (13)	Fergus (25)	Golden Valley (10)	Rosebud (12)	Ravalli (9)
INSECT	8.7/ 1.2	1.5/ 0.1	6.2/ 0.8	---------	23.1/ 4.2	28.0/ 3.8	20.0/ 4.0	33.3/ 0.2	11.1/ Tr
Grasshoppers	6.7/ 0.9		*		*	*	*	*	
Other Insects (includes ticks & spiders)	3.8/ 0.3	*	*		*	*			*
PLANT MATERIAL[2]	45.2/13.1	44.8/19.6	35.9/14.4	37.5/ 4.8	15.4/ 2.5	44.0/ 0.6	40.0/15.3	91.7/16.2	88.9/ 4.1
Miscellaneous	38.5/ 8.7	*	*	*	*	*	*	*	*
Barley	2.9/ 1.4	*	*		*		*		
Wheatgrass	1.4/ 0.8	*	*						
Juniper Berries	1.9/ 0.5	*							
Alfalfa	0.5/ 0.5	*							
Rose Hips	1.9/ 0.3	*	*						
Needlegrass	1.4/ 0.2	*	*						
Cottonwood Leaves	1.0/ 0.2	*							
Skunkbush Sumac	0.5/ 0.2	*							
Sagebrush	1.0/ 0.1	*	*						
Chokecherries	1.0/ 0.1		*			*			
Lichen	0.5/ Tr	*							
Unidentified Seeds	0.5/ Tr			*					
MISCELLANEOUS	21.6/ 7.9	13.4/ 7.2	17.2/10.6	25.0/20.0	7.7/ 2.2	36.0/6.4	20.0/ 7.8	75.0/ 0.5	22.2/ 3.9
Trap Bait	3.8/ 3.2	*	*						
Coyote Feet, Hair, Etc.	5.6/ 1.8	*	*			*	*	*	
Misc. Fat, Bone, etc.	5.3/ 0.9	*	*			*		*	
Commercial Feed Pellets	1.0/ 0.6	*	*						
Dirt, Rocks, etc.	3.8/ 0.6			*		*		*	*
Milk Carton	0.5/ 0.3			*					
Manure	1.4/ 0.3					*	*		
Cloth, Canvass, etc.	0.5/ 0.1				*				
Old Harness Leather	0.5/ 0.1								*
UNIDENTIFIED	32.2/ 3.5	35.8/ 4.2	48.4/ 5.2	50.0/5.6	38.5/ 3.2	---------	30.0/ 3.2	---------	---------

[1]A good deal of the food items in certain other categories probably were carrion as well, but there was no way to determine origin. Items are designated carrion using several criteria such as presence of fly larvae (maggots) and/or pupae; lack of fresh meat or skin; presence of items such as fresh bird feet with little or none of the rest of the birds; etc.

[2]Much of the miscellaneous plant material was from trapped animals which chew and swallow almost anything within reach (this is also the source of some of the identified plant material as well as such things as coyote feet and dirt, rocks, etc.). Some of the other plant material is accidentally ingested while capturing and eating prey animals, although some (barley, juniper berries, rosehips, etc.) are obviously taken on purpose.

Appendix Table 7. Winter 1975-76 food habits from stomach sample analysis. Only locations with 10 or more samples are included. Figures are percent frequency of occurrence/percent of total diet, Tr denotes less than 0.05 percent.

Item	Total[1] (394)	Bull Mtns. Musselshell Co. (159)	Lake and Sanders Co. (62)	N. E. Fergus Co. (36)	Valley County North (19)	Valley County South (25)	Powder River Co. (31)	Meagher Co. (19)	Northeast Gallatin Co. (10)
Rodent	70/38.7	70/34.4	87/75.1	56/24.0	63/29.2	88/33.4	58/19.5	84/70.4	100/52.7
Rabbit	21/14.3	28/17.8	2/ 0.3	17/14.1	63/47.1	32/24.7	23/15.0	-/-	10/ 2.0
Other Mammal[2]	63/42.1	70/43.6	39/16.3	72/49.9	32/18.8	56/37.3	93/65.1	47/29.6	50/44.9
Cattle	21.0	23.9	11.2	19.9	18.8	9.5	42.7	16.1	19.5
Deer[3]	11.0	4.9	5.1	30.0			20.2	13.5	25.4
Antelope	2.2	1.9				22.2			
Domestic Sheep	4.3	8.9[4]					2.3		
Bird	14/ 2.7	16/ 2.5	15/ 2.6	14/ 6.4	11/ 2.1	12/ 4.4	16/ 0.4	5/Tr	10/Tr
Invertebrates	2/Tr	3/ 0.1	-/-	3/Tr	-/-	4/Tr	-/-	-/-	-/-
Vegetation	6/ 0.5	4/ 0.1	19/ 3.3	11/ 0.1	5/ 0.1	-/-	-/-	-/-	-/-
Miscellaneous	10/ 1.7	11/ 1.6	11/ 2.5	25/ 5.4	11/ 2.7	8/ 0.2	3/Tr	5/Tr	10/ 0.4

[1]Includes 33 from various areas not individually listed.
[2]Includes a large amount of carrion.
[3]Includes both mule and white-tailed deer.
[4]Includes an unknown but relatively large percentage of trap bait and/or carrion.

APPENDIX II

JOB PROGRESS REPORT

RESEARCH PROJECT SEGMENT

STATE Montana

PROJECT W-120-R-11 (5893) TITLE Statewide Wildlife Research

PROGRAM III TITLE Non-game animal research

STUDY NO. NG-47.1 TITLE The effects of coyotes on big game populations in Montana

JOB NOS. 7-9 TITLE Effects of coyote predation on big game populations in the Missouri Breaks of central Montana

Period Covered: July 1, 1979 - June 30, 1980

Prepared by: Duane Pyrah

Approved by: John P. Weigand

Eugene O. Allen

Date: September 25, 1980

Since this is a Progress Report only, results presented herein are not necessarily final and may be subject to change. For this reason, the information contained in this report may not be published or used for other purposes without permission of the Director.

JOB TITLE	The effects of coyotes on mule deer production in the Missouri Breaks.
SUB-JOB TITLE	Coyote population study.
JOB OBJECTIVES	The general objective is to determine the relation between coyote density and predatory losses of mule deer to coyotes. The specific objective is to determine whether a reduction in coyotes of 50 percent or greater will increase mule deer survival, particularly survival of fawns.

INTRODUCTION

Mule deer (*Odocoileus hemionus*), with high economic, recreational, and aesthetic values to humans, comprise an important renewable natural resource in Montana. Montana's hunters have reaped heavily from the benefits accruing from their use of this resource. However, with the mid-1970's decline of mule deer populations in Montana, residents from many different walks of life were naturally concerned: fewer deer meant reduced enjoyment due to less resource benefits.

Frequently listed among the possible causes for reduced deer available to hunters was coyote (*Canis latrans*) predation. Specific predation studies in Texas (Knowlton 1968) and Oregon (Trainer et al. 1978) as well as in Montana (Knowles 1976) implicated coyotes in direct deer mortality.

The general objective of this study was to determine the relation between coyote density and the amount of coyote predation on mule deer. The specific objective was to determine whether a reduction of 50 percent or more in the coyote breeding population would result in an increase in mule deer production, particularly an increase in fawn survival.

The statewide deer study was launched in 1975 with the study of coyote predation on mule deer in the Missouri Breaks as one phase, which was started during the winter of 1975-76. Mule deer population dynamics in the Missouri Breaks were studied concurrently (Hamlin 1976-79).

The coyote predation study plan involved: coyote population measurement by scent post surveys, food habits by analysis of scats and stomach contents, productivity by examination of uterine scars, age distribution from tooth sections, mortality of radio equipped fawns, abundance of alternate prey, winter deer predation, and movements of radio equipped adult coyotes. Laboratory work on food habits, age distribution, and uterine examinations were done by Schladweiler in Bozeman and are reported elsewhere. Intensive telemetry of deer fawns to determine mortality was done by graduate students Arnold Dood (1978) and Shawn Riley (in progress). Prey abundance was studied by Trout (1978) and Hamlin (1979). More intensive telemetry of adult coyotes in the Missouri Breaks was undertaken during 1977 to determine distribution of social units, which also provided a new approach to population measurement. Development and improvement of a coyote survey method became a high priority to determine distribution, population dynamics, and potential control levels and methods.

JOB TITLE

The effects of coyotes on mule deer production in the Missouri Breaks

SUB-JOB TITLE

Coyote population study

ABSTRACT

Social distribution and population dynamics of coyotes were studied in the Missouri Breaks of central Montana from 1976 to 1979. Relocations of radio-marked coyotes indicated four adult social classes: den breeders, supernumary den nonbreeders, nomads, and dispersers. Den coyotes occupied apparent den area territories during summer which averaged 3.0 mi^2 for females and 3.2 mi^2 for males. Nomad coyotes travelled extensively over several den areas. Nomad travel areas averaged 56.4 mi^2 for males and 29.1 mi^2 for females. Dispersing coyotes were killed at distances ranging from 8 to 95 mi from their original (den area?) trap sites. Coyote density was estimated by siren responses and by den area estimates. Density of coyotes averaged 1.0 mi^2 during 1977-79. Siren survey density averaged 55 percent (range, 43 to 63) of the estimated population density. However, siren survey responses averaged 67 percent (range, 58 to 78) of the total coyotes where den areas were within the range of listening stations. The siren method of coyote survey appears to provide reasonable indices of coyote abundance that are related to the sample area. Guidelines and assumptions of the survey are listed. The coyote population appears to be reasonably stable. Population control appears to be by: 1) restriction of the number of den areas, due to social spacing; 2) dispersal of juveniles; 3) dispersal of adults; and 4) food relationships. Coyote predation on deer is discussed. Coyote-caused deer mortality indicated an apparent predation cycle related to "cyclic" abundance of small mammals. Observed winter deer loss was highest during 1975-76 followed by 1976-77 (1974-75 predation may have been near the level of these 2 years). Winter deer mortality was minimal during 1977-78 through 1979-80 which included two of the harshest winters on record. Mortality of radio marked fawns was likewise highest during 1976-77, and lowest during 1978-79. An irruption of microtines during 1978-79, apparently triggered by precipitation much above normal during 1978, was the apparent cause of reduced summer fawn mortality and possibly contributed to lower predation on all deer.

A period of coyote control was planned to reduce coyote populations by 50 percent. However, exceptionally low coyote predation on deer fawns, resulting in high fawn survival during the summers of 1978 and 1979, coincided with a population irruption of microtines on the study area and established that coyote population reduction could not significantly increase the already high deer production existing at that time. A control phase study would have to be delayed until coyotes again increased their predation on deer.

This report presents findings primarily related to surveys to determine coyote population levels in the Missouri Breaks during the study. These data will be integrated with results of deer and small mammal population studies to develop conclusions regarding predator prey relationships in the Missouri Breaks. Much of the data will be or has been reported by others: fawn mortality (Dood 1978 and Riley in progress), laboratory studies (Schladweiler 1975-1980), deer populations (Hamlin 1976-1979), and small mammals (Trout 1978).

ACKNOWLEDGEMENTS

Much of the data in this report is the product of unselfish cooperation and assistance of many people. They also offered ideas as well as being critics of ideas being developed. Their extra efforts are much appreciated.

Ken Hamlin assisted with all study phases: trapping and marking of coyotes, radio location, radio construction, siren surveys, scent post surveys, winter predation flights, and location of pups, dens, and marked coyotes during his deer surveys.

Larry Schweitzer flew most of our flights for locating radios, predation kills, trapped coyotes, and deer fawns (when many dens and litters were found). His exceptional flying and observational skills, interest in the study and study subject, and knowledge of coyotes enabled us to do a better job.

Craig Knowles trapped the first coyotes in 1976, located them during the spring, ran the scent post surveys, and assisted with the initial siren surveys. Pam Knowles also assisted in trapping. Willie Steerey assisted in trapping during 1979.

The U.S. Fish and Wildlife Service (USFWS) (Jim Hoover, Dale Meeks and Dennis Abbey) provided traps, made the original sets each year, and supplied attractants. The Denver Lab (Dr. Peter Savarie) supplied Tranvet for tranquilizer tabs. Gary Huschle of the Charles M. Russell National Wildlife Refuge staff was interested in and assisted with siren surveys.

John Gilpatrick, a Lewistown rancher, loaned his Federal Model 28 siren, saved coyote carcasses, provided locations of coyotes taken, and provided much valuable information that he had gleaned from many years of hunting coyotes.

Arnold Dood and Shawn Riley assisted with siren and scent post surveys and provided locations of coyote litters found during radio location of fawns.

Phil Schladweiler designed and built the first radio collars; John Mundinger also assisted with radio construction. Terry Lonner ordered radio supplies, and kept the radio frequencies organized.

Phil Lehner (Colorado State University), Craig Sharpe, and Tom Warren provided tapes of coyote calls which we were unable to test against the siren responses.

The manuscript was reviewed by Ken Hamlin, John Gilpatrick, John Weigand and Phil Schladweiler.

STUDY AREA

The Missouri Breaks coyote study area is located on both sides of the Missouri River in northcentral Montana, Figure 1. Vegetation, topography, land use, and wildlife have been discussed in detail by Mackie (1970), Knowles (1975) and Komberec (1976).

South Missouri Breaks

The South Missouri Breaks includes approximately 200 mi^2 in northeastern Fergus County, extending (north to south) from the Missouri River to Crooked Creek and (west to east) from Highway 191 to the Skyline Trail (near the Fergus-Petroleum County line).

The Musselshell Trail, following the general drainage divide between the Missouri River and Crooked Creek, divides the South Missouri Breaks into: 115 mi^2 of fir-pine-juniper "breaks" (along coulee sideslopes) and sagebrush/grass "finger ridges" or "benches", and 85 mi^2 of continuous sagebrush/grass plains, extending to and beyond Crooked Creek (Fig. 2).

The coulee breaks, along with their interspersed finger ridges, comprise the main coyote and deer habitats. This was the primary study area where coyote studies of radio telemetry, population distribution, population dynamics, siren surveys, and scent post surveys were conducted.

Fir/juniper habitat type (PSME / JUSC, *Pseudotsuga menziesii/Juniperus scopulorum*) or pine/juniper habitat type (PIPO/JUSC, *Pinus ponderosa/Juniperus scopulorum*) (Roberts and Sibbernsen 1979) covers much of the coulee side slopes and combined with the sagebrush/grass (ARTR/AGSP, *Artemisia tridentata/Agropyron spicatum*) finger ridges makes up the composite matrix of the "breaks" habitat complex (Fig. 3). Trees decrease gradually toward heads of coulees and prairie uplands. Some steep south slopes are predominantly exposed raw shale which are periodically covered with sweet clover (*Melilotus officinalis*). Other habitat types occur as small inclusions within the primary breaks habitat. These other types include: mesic stringers of snowberry/western wheatgrass (SYOC/AGSM, *Symphoricarpos occidentalis/Agropyron smithii*), greasewood/rabbitbrush (SAVE/CHNA, *Sarcobatus vermiculatus/Chrysothamnus nauseosus*), and less important types. Greasewood is commonly a bottomland type but in the Missouri Breaks it also occurs on saline side slopes and mixed with sagebrush on ridges. Some of the pine/juniper may be *Pinus flexilis/Juniperus scopulorum* indicating the aridity of the area.

Although little research has been done on the specific benefits of juniper as wildlife food and cover in this area, the close association of deer (especially fawns), cottontails, and coyotes with dense juniper plants would indicate that this is a key wildlife plant in these communities. Snowberry is also an important plant for fawn bedding cover.

The continuous sagebrush/grass plains provide primary habitat for pronghorn antelope and secondary habitat for coyotes and deer.

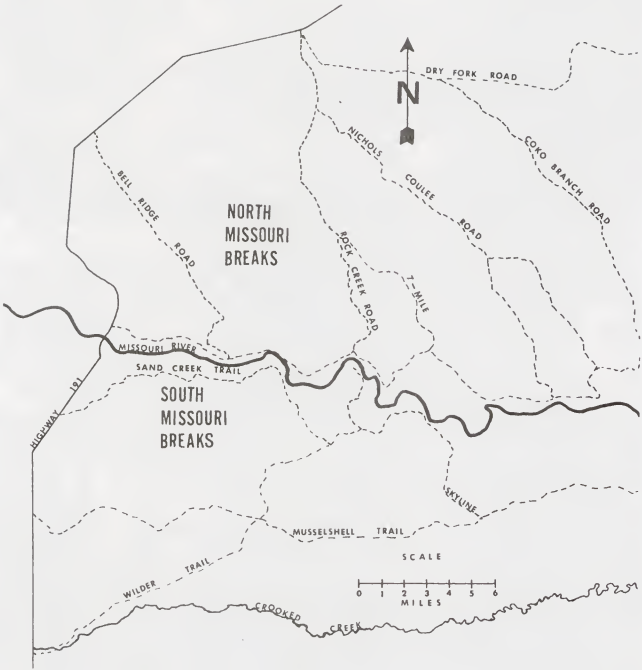

Figure 1. The Missouri Breaks coyote study area.

Figure 2. Aerial mosaic of the South Missouri Breaks (SCS photo).

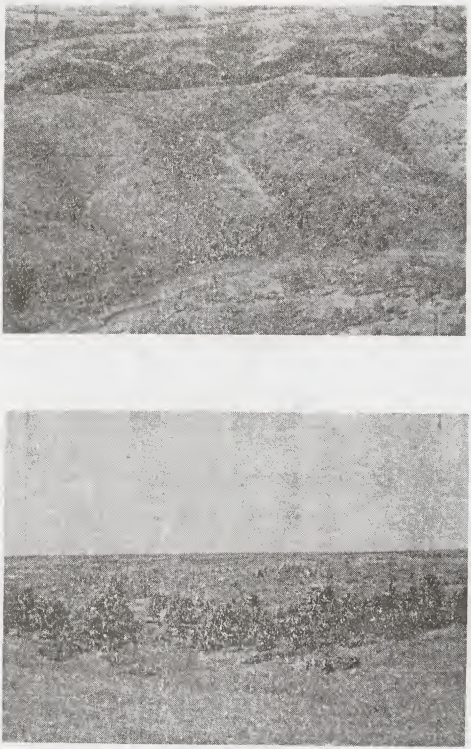

Figure 3. Photographs of "breaks" habitat.

One important but highly variable habitat condition in both breaks and prairie is the presence, or absence, abundance and phenological state of sweetclover. This plant grows profusely during years when moisture conditions favor its biennial life cycle. The undependable abundance of sweetclover modifies habitat conditions for nearly all animals.

Livestock grazing is the principal commercial land use. Recreational pursuits of hunting, fishing, and camping are the important noncommercial public uses. The land area adjacent to the Missouri River lies within the Charles M. Russell National Wildlife Refuge, administered by the U.S. Fish and Wildlife Service. Public lands over the remainder of the area are administered by the U.S. Bureau of Land Management through the East Indian Butte and Crooked Creek Grazing Districts, which also control management on the interspersed private and state land.

North Missouri Breaks

The North Missouri Breaks included approximately 280 mi^2 in southwestern Phillips County extending (south to north) from the Missouri River to the Dry Fork Road and (west to east) from Highway 191 to the Coko Branch Road (CK Ridge). Scent post and siren surveys were conducted on this study area.

Major drainages north of the Misssouri River are longer, thereby increasing the distance between the river road and the next east-west road 14 miles from the river. Northside ridges have more areas covered with glacial till; soils are more gravelly and support slightly different plant communities. Otherwise, vegetation, land ownership and land use are similar to the South Missouri Breaks.

Nichols Coulee and Square Butte Resource Conservation Areas cover most of the north study area, including portions of the CMR National Wildlife Refuge.

METHODS

General Observations

Locations of observed coyotes were recorded during all phases of field activities in the South Missouri Breaks. These activities included helicopter deer surveys, fixed wing aerial location of fawns, livestock, and deer, and ground travel for deer trapping, fawn tagging, radio relocations, den watching, coyote trapping, and siren and scent post surveys. All coyote observations on the South Missouri Breaks were referenced to a gridded (2 in/mi) aerial mosaic (enlargement of Fig. 2).

Scent Post Surveys

Scent post surveys were conducted during May, July, and September for 1976-78. Standard USFWS materials and procedures were used (Roughton 1976). Fifty scent post stations were placed at 0.3 mi intervals along the Wilder Trail-Rocky Point Trail in the South Missouri Breaks, and along the Nichols Coulee Trail in the North Missouri Breaks (Fig. 1).

Siren Answer Surveys

Sirens have been used by hunters for years to elicit howls from coyotes, thus indicating their probable location. Siren elicited howls have been used as a survey technique prior to this study (Pyrah 1974, Lemos 1978).

Siren surveys were done mainly during July, August, and September from 1976 to 1979. These surveys were conducted twice on the following trails within the South Missouri Breaks: 1) Wilder-Sand Creek and 2) Musselshell-Skyline, and within the North Missouri Breaks 3) Nichols-7 Mile and 4) Bell Ridge-Rock Creek.

Siren answer surveys followed procedures recommended by the USFWS, with some slight modifications. Listening stations were 3 mi apart and assumed a listening radius of approximately 1.5 mi covering 7.07 mi^2. Wenger and Cringan (1978) recommend 1.9 mi (3.2 km) between stations; however, we were reasonably certain that we heard calls from more than 1.5 mi. A dog was definitely heard for 2.5 mi as measured between known points on the aerial mosaic. Siren surveys were started near midnight (due to low response between dark and midnight during previous surveys) and concluded between 0300 to 0430 MDT. The listening time varied at each station, depending upon the number of coyotes heard. A listening period of 2 min (as recommended) followed each siren wail of 20 sec (7 sec of maximum plus 13 sec of run down), however, listening was continued until all answering coyotes were identified or ceased to call. This time sometimes exceeded 5 minutes.

Coyote howls were recorded as to number, direction, and distance. One or two coyotes were easily recognized. Recognition of three coyotes was based on hearing three different calls at the same time. More than three coyotes were estimated by the amount and confusion of the howling. Directions were on the basis of the eight primary directions. Distance was based on three classes: loud and close, 1/2 mi; clear and moderately loud, 1 mi; and audible but difficult to distinguish, 1 1/2 mi.

The objective of the survey was to record a response from as high a percentage of the coyotes within listening range of each station as possible; therefore, the listening time interval was interpreted toward that objective. The siren was placed on a moveable platform on top of the truck cab so it could be rotated toward each side of the truck or road. Directing the siren in a quartering direction would reduce the bias or distortion of the listening radius caused when the siren was pointed directly ahead of the truck each time.

Initially siren surveys were analyzed on the basis of the average number of calls heard per station. That approach was modified to the highest count obtained for the whole route. Further analysis indicated that one end of the route might be high on one survey and the other end high during another survey. The distance separating listening stations plus the stable social distribution of coyotes (see later section) indicated that separate coyotes were being counted. Thus, further analysis was made on the highest count for each station on the route.

Den Area Estimates

Population estimates for the South Missouri Breaks during 1977-79 were made by combining information from several sources: 1) all adult coyotes, both marked and unmarked, associated with litters, 2) coyotes trapped and marked, compared to unmarked coyotes, 3) all den areas known or with reasonably clear evidence of litters (lactating females, siren multiple calls, pup scats or tracks, or a "halo" where the ground is so trampled around the den as to indicate presence of a litter), 4) coyotes observed during other field operations, 5) and the average number of young in probable complete litters.

All siren multiple answers were not included in earlier den area estimates, however, it was necessary to do so to make the year to year data comparable. Thus all den areas where multiple answers (3 or more) were heard were considered as occupied den areas.

Coyotes answering in breaks habitat were recorded separately from those answering in prairie habitat. Coyotes answering outside of the study area (except those probably associated with den areas A and I) were excluded from the den area estimates for the study area population. These coyotes were included in the siren survey estimates of density.

Trapping

Initial trap sets were made by USFWS trappers, Dale Meeks in 1976, 1978 and 1979 and Dennis Abbey in 1977. Traps were subsequently reset and moved to new locations by project personnel. Traps were No. 3, double-spring, leg-hold, coyote traps with off-set jaws. The trap setting procedure was similar to that described by Young (pp: 187-193 *In*: Young and Jackson 1951). Coyote urine and other scents were used as attractants. Tranquilizer tabs (Balser 1965) were attached to traps during 1978 and 1979. Traps were visited every day when possible. Traps were checked by ground or air travel.

A procedure was developed which allowed safe handling of each coyote with a minimum of difficulty or risk of being bitten. The procedure consisted of: 1) placing a pole-choke noose around the coyote's neck, usually causing it to lay down; 2) placing a canvas over the coyote; 3) grasping the coyote's muzzle by running the hand forward along the back, neck, and head to locate and grasp the muzzle; 4) moving the canvas back to expose the bare muzzle and grasping the muzzle shut without the canvas over it; 5) taping the muzzle shut with plastic electrician's tape (3-M); and 6) taping the three free feet together (Fig. 4). The caught foot was then released and the coyote could be moved and handled safely and conveniently without tranquilizer or anaesthetic injection. Coyotes were placed in shade during sunny, warm weather while the radio collar was being fitted. The submissive behavior of coyotes, when covered by a canvas, was first pointed out by Knowles while trapping in 1976.

Marking

VHF radios (AVM Electronics Co.) were potted with lithium chloride batteries in dental acrylic and attached to Koroseal (Goodrich) collars following the design of Schladweiler in 1976. Neck fur was trimmed with scissors to make the collar fit better. The ends of the collar were fastened together with pop rivets. Telonics made the completed radios used during 1979. Koroseal collars with bellshaped cattle tags were put on juveniles during fall of 1978.

Radio Telemetry

Radio relocations were made from ground and air. Aerial locations were on a 1-2 week basis. Ground locations were made while working on another activity.

For aerial locations, a 4-element yagi antenna was taped to the airplane wing strut with the coaxial antenna cable extending to the receiver held by the observer inside the airplane. Earphones were worn by the pilot and observer so both could monitor signals. Coyotes were not always observed, due to their easy concealment in various cover situations; however, their location was

Figure 4. Investigator prepares a Koroseal collar to mark a trapped coyote, a Koroseal radio collar is to the right of the coyote's head. (Phote courtesy of Frank Martin).

determined within a very small area by the strength of the radio signal. On two occasions radios on the ground were found by foot search to be within 100 yd of the location determined from the airplane.

Predation Surveys

Following Knowles (1976) documentation of high winter predation by coyotes on deer, particularly on or near ice over the Missouri River and Fort Peck Reservoir, approximately weekly flights were made during winter along the river and reservoir to locate coyote kills. Most kills were inspected to determine prey species. Few had more than hair, rumen, and occasional bone pieces remaining. Old kill sites were recognizable for long periods due to coyotes digging up the hair or rumen, and blood remaining frozen in the ice.

RESULTS

General Observations

General observations in 1976 to 1978 were plotted on an acetate overlay of the study area mosaic. These observations were strongly clustered in the breaks habitat of the primary deer and coyote study area between the Missouri River and the Musselshell Trail. Observations were also strongly biased to areas where radio marked coyotes were located. The timbered areas of pine/juniper and fir/juniper were the most used habitats. Since coyotes were not observed, or tracked with radios, during the night, their nighttime activities probably included much more of the open habitat, similar to deer in the Decker area (Biggens 1976). Very strong observational bias precluded using these observations in any analysis other than generalizations.

Social Distribution

Thirty-seven coyotes were trapped and marked to study social distribution. Twenty-six were fitted with radios and 11 with collars, as follows: 1976 - 5 radios, 1977 - 10 radios, 1978 - 7 radios and 11 collars, and 1979 - 4 radios.

Adult coyotes (excluding juveniles) were considered to be in four distinct social categories: den pairs (breeders) - sometimes with one or more supernumary den adults (nonbreeders), nomads, and dispersers. An adult coyote may change social status to any of these during its lifetime. Juvenile coyotes constitute a special temporary social state. Young of the year during den and rendezvous stages are not directly important in predation on deer. Social status of den and nomad coyotes was determined by telemetry of radio marked individuals. Dispersal was determined by telemetry and return of markers.

Den coyotes exhibited restricted movement patterns which were limited by the presence and location of litters and the occupied areas of neighboring coyotes. The average den area for three lactating females was 3.1 mi^2, and for eight males it was 3.2 mi^2 (Table 1, Figure 5). These were observed an average of 331 days (33 relocations) for females and 336 days (33 relocations) for males. A "t" test indicated that the average den area size was not significantly different ($P < 0.05$) between sexes. These den areas are larger than those (1.9 and 2.8 mi^2) reported by Camenzind (1978) and smaller than those (5.5 mi^2) reported by Bekoff and Wells (1980).

Table 1. Relocation summary for radio-marked den coyotes in the South Missouri Breaks, 1976-80.

Den Coyotes Symbol	Den Area	Radio	Date Trapped	Last Located	Days Observation	Number Relocations	Den Area (Mi^2)	Remarks
Females								Left den area 1/13-21/77
A	E	1-3	4/27/76	1/13/77	261	35	3.6	Trapped outside 1/21/77
B	B	1-10	4/29/77	6/15/78	412	33	2.8	
C	D	4-11	5/24/79	4/9/80[1]	321	31	2.7	
				Average	331	33	3.1*	
Males								
D	P	1-6	4/29/76	8/19/76	112	11	1.4[2]	Shot out of den area 10/6/76
E	C	2-7	4/17/77	6/28/77	75	8	1.3[2]	Shot near den area 12/79
F	Q	2-10	4/21/77	12/26/77	249	26	2.1	Left den area 10/11-11/11/77 Trapped outside 9/5/78
G	J	2-3	4/22/77	4/27/78	370	41	2.7	Shot out of den area 1/14/79
H	P	1-9	5/4/77	8/28/78	481	31	4.9	
I	Q	4-5	6/11/78	10/12/79	488	52	6.0	
J	E	4-3	10/8/78	7/25/79	290	29	2.1	Left den, became nomad 7/25-8/13/79
K	O	3-11	5/14/79	10/18/79	157	21	1.5	
L	J	4-7	5/19/79	4/9/80[1]	326	33	2.4	
M	E	4-8	5/21/79	4/9/80[1]	324	33	4.2[2]	
N	G	4-9	6/27/78	8/28/78	62	3	.1[2]	
O	H	4-4	7/10/78	10/16/78	98	8	.7[2]	Left den area, became nomad 10/16-10/20/78
				Average	336	33	3.2*	

[1] Radio still operating on 4/9/80.

[2] Incomplete, not included in the averages.

* Means not significantly different; t=0.6378.

Figure 5. The South Missouri Breaks, showing siren route stations (squares w/numbers), probable den areas (circles w/letters), relocations of den coyotes (letters), observed den areas (enclosures), and litters observed for the first time each year (stars). The background (+) grid is 1 mile.

Figure 5 shows that most of the marked den adults remained in their den area or close to it while they were being observed, including two successive den seasons for six coyotes.

Nomad coyotes exhibited wide ranging movement patterns, frequently crossing several den areas (Fig. 6). The average travel area for two nonlactating nomad females was 29.1 mi^2. The average travel area for three nomad males was 56.4 mi^2. These coyotes were observed an average of 324 days (26 relocations) for the females and 370 days (34 relocations) for the males (Table 2). These travel areas are larger than reported by Bekoff and Wells (1980).

Dispersers of all ages exhibited long distance movements in one direction away from the study area. Table 3 indicates wide variability in dispersal distance. Most of these coyotes were killed at these distances from their den area and should not be interpreted as representing the dispersal potential for coyotes. One coyote travelled approximately 95 mi, two, 50 mi, four, 15 to 18 mi, and one, 8 mi. Dispersal was in all directions.

Three periods of coyote dispersal were observed. The most intensive was during October when young of the year left the den area, similar to red fox (Phillips et al. 1972). The two radioed juveniles dispersed during October; however, the dispersal period appears to last longer than that. Juveniles may have a predispersal investigative period starting during August when they actually leave litter mates but remain in or near the den area. Another period involves supernumary adults leaving the den area when juveniles begin travelling. Two radioed coyotes in this category left the den area and became apparent nomads during August (J) and October (V). Some adult coyotes left the den area after the dispersal of young. Two coyotes with damaged feet left the den area during October (F) and January (A). One other coyote (G) travelled as a nomad during fall and winter, apparently after litter dispersal.

Dispersal coyotes were all killed by hunters, at least partially attributable to the low security of the dispersal areas surrounding the breaks habitat. With one possible exception, only one marked coyote (E) in breaks habitat was taken within its own den area.

Population Surveys

Coyote abundance was measured by a siren response survey (Table 4). Since this technique was being developed during the study, the data have some defects, which were dealt with as they became apparent.

The average fall density by siren survey was .57/mi^2. Averages on the south (.60) and north (.54) indicated similar densities of coyotes. Differences between routes and areas were not significant ($P < 0.05$) ("t" test) but the sample was small.

The decrease and subsequent increase in the population is indicated by the density of responding coyotes. The coyote population was approximately the same during 1976 and 1979. The level of coyotes seen and shot by hunters would indicate a higher population may have existed during 1975 and possibly 1974. The lowest population appears to have been 1977. Some recovery appears to have occurred during 1978.

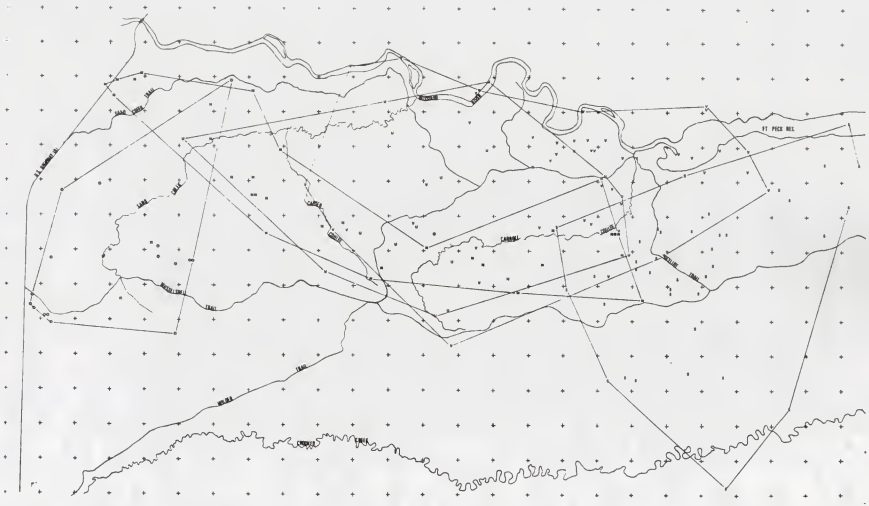

Figure 6. The South Missouri Breaks, showing relocations of radio nomad coyotes (letters) and their probable travel areas (enclosures). The background grid (+) is one mile.

Table 2. Relocation summary for radio-marked nomad coyotes in the South Missouri Breaks, 1976-79.

Nomad Coyotes Symbol	Radio	Date Trapped	Last Located	Days Observed	Number Relocations	Nomad Travel Areas (mi^2)
Females						
N	1-8	5/5/76	6/3/77	394	32	34.8 1979,1980 in den area "O"
O	1-5	4/16/77	12/26/77	255	21	23.4
P	2-12 1/	4/25/77	4/28/77	1/	1/	1/
Q	2-1 1/	4/26/77	7/5/77	70 1/	3 1/	1/
R	4-1 1/	7/10/78	7/22/78	12 1/	4 1/	1/
			Average	324	26	29.1
Males						
S	1-12	5/3/76	6/19/77	403	37	51.9
T	1-4 1/	5/15/76	11/24/76	app. 193	6 1/	1/ radio intermittent
U	2-9	4/3/77	12/27/77	241	18	52.2
J	4-3 1/	7/25/79	10/18/79	85 1/	12 1/	5.6 1/
V	4-4	7/10/78	10/18/79	465	46	65.3
			Average	370	34	56.4

1/ Incomplete, not included in the averages.

Table 3. Summary of dispersal movements of marked coyotes from the South Missouri Breaks.

Marker	Date Trapped	Last Location	Interval Days	Travel Distance (miles)
2-10	4/21/77	9/15/78	512	18
R-44	10/ 5/78	2/ 2/79	112	50
2-9	4/30/77	10/28/79	911	16
R-41	10/16/78	7/17/79	274	95
R-45	10/12/78	12/18/79	432	50
4-2	9/29/78	11/21/78	53	8
4-6	10/ 6/78	1/16/79	102	15
R-42	10/ 9/78	12/79	417+	15

The very severe winters of 1977-78 and 1978-79 may have reduced winter food availability for coyotes and thus prevented them from capitalizing on the food bonanza presented by the vole irruption.

During 1976, the data for the Rock Creek - Bell Ridge route was arbitrarily doubled because the route was surveyed only once and repeated surveys on this and other routes indicated a low survey. The results would be as much or more in error if they were left unchanged. Due to these conditions, this set of 1976 data was not used in any analysis.

During 1979, the data for the Musselshell - Skyline route was doubled to depict coyote density in breaks habitat when analysis of the route responses indicated that most of the prairie half of each station was no longer occupied by resident coyote families and nearly all coyote answers came only from the breaks half of each station. This route follows the border between the breaks and prairie habitats, one-half of each type being sampled by each station. High hunter kill of coyotes occurred during winter of 1978-79, when hunters with airplanes and snowmobiles, aided by record deep snow, severely reduced the prairie coyotes.

The scent post survey was abandoned due to its poor reflection of occupied den areas. Visits were not observed at many scent stations in den areas where other coyote signs were seen and/or heard. Some of the higher scent station counts resulted from repeat visits, usually by one or more pups from the same litter. Mech (1979) found nomad wolves to be more investigative of scent marks left by territorial wolves.

Coyotes which were accounted for by observations or estimates in den areas which were known to be occupied, appear in Table 5. Occupied den areas progressed from 13 (1977) to 16 (1978) to 19 (1979) and total den area coyotes in the breaks habitat from 80 (1977) to 94 (1978) to 103 (1979). As more den areas became apparent, more litters were observed. In 1977, 5/13 were found, in 1978-8/16 and 1979-11/19. These estimates also indicate an increase from 42 young in 1977 to 60 in 1978 and 61 in 1979.

Table 4. Summary of siren survey coyote responses for high counts at each station, Missouri Breaks study area, 1976-1979.

Area and Route	Year	Number of Coyotes (C)	Number of Stations (S)	Average Coyotes Per Station (C/S)	Density of Response Coyotes (Mi^2)
So. Missouri Breaks					
Wilder-Sand Cr.	1976	56	11	5.09	.72
	1977	51	12	4.25	.60
	1978	35	12	2.92	.41
	1979	56	12	4.67	.66
Musselshell-Skyline	1976	50	10	5.00	.71
	1977	33	10	3.30	.47
	1978	40	11	3.64	.51
	1979[1]	56[1]	11	5.09[1]	.72[1]
South Subtotals	1976	106	21	5.05	.71
	1977	84	22	3.82	.54
	1978	75	23	3.26	.46
	1979	112	23	4.87	.69
No. Missouri Breaks					
Rock Cr.-Bell Rd.	1976[1]	34[1]	10	3.40[1]	.48[1]
	1977	36	10	3.60	.51
	1978	29	10	2.90	.41
	1979	60	10	6.00	.85
Nichols-7 Mile	1976	40	12	3.33	.47
	1977	21	10	2.10	.30
	1978	53	12	4.42	.62
	1979	48	11	4.36	.62
North Subtotals	1976	74	22	3.36	.48
	1977	57	20	2.85	.40
	1978	82	22	3.73	.53
	1979	108	21	5.14	.73
Missouri Breaks Totals	1976	180	43	4.19	.59
	1977	141	42	3.36	.47
	1978	157	45	.49	.49
	1979	220	44	5.00	.71

[1] Adjusted, see narrative.

Table 5. Den area estimates for coyotes in breaks type habitat within the South Missouri Breaks, 1977-79. Young representing complete litters are shown by whole numbers, but where a complete count of a litter was not obtained the average for complete litters that year is used.

Den Area Name	Symbol	1977			1978			1979		
		Adults	Young	Total	Adults	Young	Total	Adults	Young	Total
Highway Grade	A	3	3.2	6.2				2	3.2	5.2
Gumbo Ridge	B	3	3.2	6.2	2	3.8	5.8	2	3.2	5.2
King Island	C	2	3.2	5.2	2	3.8	5.8	4	2	6
Doney Bottom	D				2	3.8	5.8	2	3	5
L. Sand Creek	E	2	3.2	5.2	2	3.8	5.8	3	4	7
Johnson Bottom	F							2	4	6
Rocky Point	G	6	3.2	9.2	2	5	7	2	3.2	5.2
Hutton Bottom	H				2	4	6	3	3.2	6.2
Skyline Hogback	I	4	3	7	2	3.8	5.8	2	3	5
Carroll Crossing	J	2	4	6	2	3.8	5.8	2	6	8
Dobbs Coulee	K				2	3.8	5.8	2	3.2	5.2
Lance's Ridge	L							2	4	6
Mathison Place	M	2	3.2	5.2	2	6	8	2	3.2	5.2
Haines Coulee	N				2	4	6	2	1	3
Six Mile	O	2	3.2	5.2	2	3.8	5.8	2	4	6
Upper Carter	P	2	3	5	2	4	6	2	3	5
Sagebrush Pasture	Q	4	3	7	2	3	5	2	1	3
U. Sand Creek	R	3	3	6	3	2	5	2	3.2	5.2
White Coulee	S	3	3.2	6.2	3	2	5	2	3.2	5.2
TOTALS		38	41.6	79.6	34	60.4	94.4	42	60.6	102.6
Occupied Dens				13			16			19

Predation Surveys

Aerial predation surveys were made during winter along the Missouri River and Fort Peck Reservoir. Predator kills on upland were included when they were found. It was not considered feasible to frequently survey the uplands for predator kills.

High winter deer mortality caused by coyotes and reported by Knowles (1976) as well as the report on coyote depredation on deer in the CMR National Wildlife Refuge (Calvert 1975) indicated a need to survey this activity on a long-term basis.

During this study, the highest winter loss of mule deer occurred during 1975-76. Deer loss declined in 1976-77 and was very minimal during 1977-78 through 1979-80 (Table 6).

Table 6. Probable coyote-killed big game animals found during winter (December-March), 1975-80.

	Uplands	Bottomlands	River Ice	Reservoir Ice	TOTAL[1]
Mule Deer					
1975-76	9	2	1	33	45
1976-77	4	0	3	9	16
1977-78	5	0	2	1	8
1978-79	4	0	1	1	6
1979-80	0	0	4	3	7
White-tailed Deer					
1975-76	1	10	9	0	20
1976-77	0	1	3	0	4
1977-78	0	1	0	0	1
1978-79	0	1	1	0	2
1979-80	0	0	1	0	1
Antelope					
1978-79	27	0	0	3	30

[1] 1 deer unclassified as to species in 1975-76.

A herd of antelope was isolated in the breaks habitat along the Sand Creek Trail during 1978-79 and sustained high coyote predation.

DISCUSSION

Social Distribution

Coyote social organization in the Missouri Breaks resembles the social descriptions given by Ryden (1975), Camenzind (1978), and Bekoff and Wells (1980) for coyotes on the National Elk Rufuge in western Wyoming. The social base for coyote production in the Missouri Breaks, however, is den pairs instead of den packs. Den pairs in the Missouri Breaks occasionally contained one or more supernumary adults (possibly mostly males and from the previous litter). Coyote trappers in this area indicate that they often find two adults together after killing one of an apparent pair. In three cases involving litters with more than two adults, one or more of which was marked, all extra coyotes were males - in two cases they were the marked males. In the other case the dominant male could not be accurately determined but the marked one appeared to be the den male.

None of four nonlactating females marked was observed with a litter in the year of capture. A 1976 nonlactating female (N) eventually became a den female; she was observed in den area "O" with a marked male (K) and 4 pups during 1979 when she would be at least 4 years old. She may have had a litter in this den area during 1978 also.

Kennelly (1978) reported that the testes of males regressed during spring following breeding. A reduction in male hormone could reduce the aggressiveness of males toward other coyotes, particularly males. Male behavior could be less agonistic which may facilitate feeding of females and young and tolerating extra coyotes in the social group. Evolution of male parental care behavior may have contributed to the cycle of gonad activity.

Coyote "J", a juvenile male, was trapped in den area "E" during fall of 1978. He remained in this den area where the apparent den male "M" was trapped during spring 1979. Both males were observed near the den, but "M" was at the den and with the pups more often. "J" left the den area during August, swam the Missouri River, and travelled about 15 mi. When located, he was only 1/4 mile from a den with 2 adults and 4 pups. He remained in this area a short time, travelled as a nomad for a while, returned to the second den area, and was subsequently shot during winter several miles from this den. Pack aggression toward intruders was discussed by Ryden (1975), Camenzind (1978), and Beckoff and Wells (1980).

The dominance hierarchy, which was established during the long breeding season, could still be honored by the social group during spring and summer. John Gilpatrick, a local coyote hunter reported (pers. comm.) that males are not always at the top of the dominance hierarchy; sometimes females are clearly dominant.

Female coyotes should have high levels of the hormone prolactin while they are nursing the pups. This hormone causes female chickens to become broody and protective of their young (Card 1952:49). Thus the female coyote could have protective aggressiveness due to the prolactin, causing her to appear "territorial" and to repulse other females (Berg and Chesness 1978), similar to Ryden's (1975) accounts of the conflict between females at the den. Such interactions between breeding and nonbreeding females might explain the low siren responses of females reported by Wenger and Cringan (1978); however, the social status of his test animals was not indicated.

Although the female might be more aggressive during litter rearing, the activities of scent marking and howling to advertise an occupied den area might still be mainly the behavior of the male (or males). Scent marking, howling, and feeding the female and litter could be done more effectively with more than one male in the den area. Extra adults could also provide the advantage of cooperating pairs in deer predation (Hamlin and Schweitzer 1979).

Extra adults at dens appeared to be more prevalent during the low year (1977) of the population cycle, which agrees with Camenzind's (1978) data. We did not try to estimate all extra adults. Some high siren counts may have included extra adults in some den areas.

Figure 5 indicates that roads on ridges may be approximate den area boundaries, which could be related to the ease of travelling and thus of scent marking also. Den areas B, C, D, H, J, and P only slightly overreach roads along the periphery of their den areas. Ridges may be selected as favorable howling sites due to greater acoustical range.

Coulee bottoms also appear to be near boundaries, with less observed coyote use on one side of the coulee than on the other side. The function of drainage bottoms as den area boundaries appear to be less clear than is the case of roads on ridges. A major drainage, such as the Missouri River, appears to be a definite boundary for den coyotes. All three coyotes known to swim across the Missouri River during summer were nomads. A den coyote male (M) swam to an island and was observed eating the eggs from a Canada goose nest.

Actual den areas were probably larger than determined by the relocations of radio coyotes. Conversely, some of the observed locations of marked coyotes were outside of their den area.

The entire study area appears to be allotted to traditional den areas. Some of the observed overlapping occurred during fall and winter when family groups were apparently loosely associated.

The 19 den areas between the Missouri River and the Musselshell Trail during 1979, an area of approximately 115 mi^2, averaged 6.1 mi^2 per den area, which was slightly larger than the average den area size determined by observations of marked coyotes. Since coyotes appear to be associated more with the timbered breaks habitat than with the sagebrush/grass prairie, reduction of 18 mi^2 of prairie habitat along the western edge and between Sand Creek and Carter Coulee would reduce the actual coyote habitat to approximately 97 mi^2 and coyote dens to 5.1 mi^2/den. This is approximately the size of pack home ranges at the National Elk Refuge (Bekoff and Wells 1980).

Den areas appeared to be traditional, being occupied year after year in approximately the same area (Table 7). Den areas in breaks habitat were occupied more regularly (3.2/4) than prairie den areas (1.9/4). Loss of the breeding pair from a den area probably would not change the size of adjacent den areas very much. The vacant den area then would probably be reoccupied by a pair from adjacent den areas. It appears that several den areas were unoccupied during 1977 and that two (D, H.) were crowded between existing den areas during the high vole years. Thus, the actual number of traditional den areas may be a few less than 19. The apparent permanence of these den areas keeps the population from taking full advantage of short term abundant food.

Table 7. Yearly occupancy of den areas in the South Missouri Breaks, 1976-79.

	1976	1977	1978	1979	Years Occupied	Average
Breaks Den Areas						
A		X		X	2	
B	X	X	X	X	4	
C	X	X	X	X	4	
D			X	X	2	
E	X	X	X	X	4	
F	X			X	2	
G	X	X	X	X	4	
H			X	X	2	
I	X	X	X	X	4	
J		X	X	X	3	
K	X		X	X	3	
L	X			X	2	
M	X	X	X	X	4	
N	X		X	X	3	
O		X	X	X	3	
P	X	X	X	X	4	
Q	X	X	X	X	4	
R	X	X	X	X	4	
S		X	X	X	3	
Total	13	13	16	19	61	3.2
Prairie Den Areas						
T1			X		1	
T	X	X	X	X	4	
U	X	X			2	
V	X		X		2	
W	X				1	
X	X	X		X	3	
Y	X				1	
Z	X				1	
Z1			X	X	2	
Total	7	3	4	3	17	1.9
South Side						
Total	20	16	20	22	78	2.8

Coyote den areas occurred in the prairie, especially during 1976, but attempts to capture and mark these den coyotes were unsuccessful. Coyotes captured in the prairie were mainly nomads.

Population Dynamics

The coyote population in the South Missouri Breaks appears to be relatively stable. Disregarding 1976 when a den area estimate was not made, the estimated average coyote population from 1977 to 1979 was 99 coyotes (range 89-105) in 97 mi^2 of habitat. High and low years (Table 8) were near the 3-year average. The coyote population in the North Missouri Breaks appears to be very similar as determined by the siren surveys.

Siren survey results indicated that the 1976 and 1979 coyote populations were approximately equal. Usable data were not available for years prior to 1976; however, indications were that the populations during 1974 and 1975 were higher (but probably not very much higher) than during the study. Data on den area sizes, average litters, and den adults certainly indicated that there was no doubling or quadrupling of the population after the ban on 1080 as was forecast by proponents of poisoning. It appears that during the period of highest coyote predation on deer, there was considerable stress from food shortage which caused coyote numbers to decline to the 1977 level. Abundant voles during 1978 and 1979 apparently allowed some population recovery.

The number of pups observed in litters is summarized in Table 9. Each occupied den area supported an average of 3.6 young. Litters with 3 or 4 young accounted for 66 percent (19/29) of all litters observed. Only 17 percent (5/29) had larger litters and an equal amount had smaller litters. Knowlton (1972) reported an inverse relationship between population density and average litter size. The average litter size in the Missouri Breaks appears to reflect the additional factors of winter condition of snow, cold, and food supply.

Numbers of adults were reasonably stable, varying from 34 to 42. Adults appeared to live longer in the breaks than is usual in other areas. A 1976 nomad male (S) was shot in 1979 (at least 4 years old) still in its 1976 nomad travel area. The 1976 nomad female (N) was still alive in 1980 and would be at least 5 years old. The 1977 den male (E) was shot in its den area in December 1979 (at least 3 years old). Many of the marked den coyotes, which have remained in the breaks, are potentially still alive (Table 10).

The coyote population in the Missouri Breaks appears to be controlled mainly by social restrictions imposed by the den areas and by the high annual attrition by dispersal. The spacing and traditional nature of den areas may keep the coyote population from declining also. The spacing of adults through den areas may reduce intraspecific competition, thereby reducing population fluctuations which result from density dependent food competition.

Dispersal is functionally the same as death as far as the population is concerned. In fact, dispersal may be tantamount to death when dispersal is to insecure habitat where coyotes can be heavily hunted. Dispersal to low security habitat not being heavily hunted may be different than was observed in the South Missouri Breaks. Dispersal in coyotes appears to be more important than in wolves (Packard and Mech 1980).

Dispersal may be benefitted by abundant food and inhibited by food shortage. Juveniles may be able to eat better when food is scarce if they can depend

Table 8. Estimated coyote population in the South Missouri Breaks, 1976-79.

Year	Den Areas:	BREAKS HABITAT																			PRAIRIE HABITAT									South Side Total
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	Total	T1	T	U	V	W	X	Y	Z	Z1	Total	
1976	Siren Answers	1	5	3	1	3	8	7	1	4		4	3	6	1		5		5		57	2	6	3	6	3	5	5	5		35	92
	Den Area Est.									5					5			9			19				5						5	
	Highest Count	1	5	3	1	3	8	7	1	5		4	3	6	5		5	9	5		71	2	6	3	6	3	5	5	5		35	106
1977	Siren Answers	4	3		1	8	2	6		1		2		6	1		1			4	39		6	5			6	1	1	2	21	60
	Den Area Est.	6.2	6.2	5.2		5.2		9.2		7	6			5.2		3.2	5	7	6	6.2	79.6											
	Highest Count	6.2	6.2	5.2	1	8	2	9.2		7	6	2		6	1	5.2	5	7	6	6.2	89.2		6	5			6	1	1	2	21	110.2
1978	Siren Answers	1	1	5		5	1	6	4	8		8	2	1	1		1	2	5		51	3	5	1	4	1	2		1	7	23	74
	Den Area Est.		5.8	5.8	5.8	5.8		7	6	5.8	5.8	5.8		8	6	5.8	6	5	5	5	94.4											
	Highest Count	1	5.8	5.8	5.8	5.8	1	7	6	8	5.8	8	2	8	6	5.8	6	5	5	5	102.8	3	5	1	4	1	2		1	7	23	125.8
1979	Siren Answers	4	4	4	6	5	6	6	5	6	7	2		4			3			5	67	1	3	1			3	1		3	12	80
	Den Area Est.	5.2	5.2	6	5	7	6	5.2	6.2	5	8	5.2	6	5.2	3	6	5	3	5.2	5.2	102.6											
	Highest Count	5.2	5.2	6	6	7	6	6	6.2	6	8	5.2	6	5.2	3	6	5	3	5.2	5.2	103.4	1	3	1			3	1		3	12	117.4

Table 9. Yearly frequency distribution of observed coyote litters in the Missouri Breaks, 1976-79.

Litter Size	1976	1977	1978	1979	Total
1				2	2
2			2	1	3
3	3	2	1	3	9
4	1	2	3	4	10
5	1		1		2
6			1	1	2
7	1				1
Total litters	6	4	8	11	29
Total young	25	14	30	35	104
Average litter	4.2	3.5	3.8	3.2	3.6

upon adults to some extent. Thus juveniles may remain with their parents or den adults which would improve their ability to obtain food. Since more supernumary adults were observed when predation on deer was highest, this may be the consequence of inhibited dispersal behavior. When juveniles remain with the adults beyond the normal dispersal time, they essentially increase the number of adults, resulting in more opportunities for cooperative hunting (Hamlin and Schweitzer 1979).

Total population loss (mortality?) can be calculated by subtracting any year's adults from the previous year's total coyotes. This loss in the Missouri Breaks accounted for 46 coyotes between 1977 and 1978 and 52 between 1978 and 1979. More coyotes were involved in dispersal from the breaks habitat than were accountable to any other loss.

Observed mortality of marked coyotes within the study area was very low. Most marked coyotes were killed at places outside of the study area; their longevity is summarized in Table 10. Some marked adult coyotes appeared to be at a disadvantage in den hierarchal conflicts (mostly due to trapping injuries), following which they became nomads and/or dispersed. These adults were killed during dispersal instead of becoming mortalities within the breaks habitat. This appeared to be true for juveniles also.

Forty-nine percent (18/37) of the marked coyotes were killed by hunters and 5 percent (2/37) died of other causes; 90 percent of the known loss was to hunters and trappers, similar to mortality reported by Clark (1972). Fifty-five percent (6/11) of collared juveniles and 46 percent (12/26) of radio marked animals (23 adults and 3 juveniles) were shot or trapped. Sixty percent (3/5) of the 1976 radio coyotes were killed, while 70 percent (7/10) of the 1977 and 56 percent of the 1978 coyotes were killed. Sixty-four percent (9/14) of the 1978 juveniles were killed. These percentages will undoubtedly be higher when mortality for these years is complete.

Table 10. Months of survival of marked coyotes in the South Missouri Breaks, 1976-1980.

Coyotes Marked				Social	Year	Time[1/]	Age in[1/]
Year	Marked	Age/Sex		Status	Killed	Alive	June 80
1976	1-12	A	M	Nomad	1978	43	
1976	1-3	A	F	Den/nomad	1976	19	
1976	1-6	A	M	Den/nomad	1976	21	
1976	1-4	A	M	Nomad			63
1976	1-8	A	F	Nomad			63
1977	1-5	A	F	Nomad			51
1977	2-10	A	M	Den/nomad	1978	30	
1977	2-3	A	M	Den	1979	34	
1977	2-7	A	M	Den	1979	45	
1977	2-12	A	F	Nomad	1977	13	
1977	2-1	A	F	Nomad	1977	15	
1977	1-10	A	F	Den			51
1977	1-7	A	M	Nomad	1977	21	
1977	2-9	A	M	Nomad	1979	43	
1977	1-9	A	M	Den			51
1978	4-5	A	M	Den			39
1978	4-9	A	M	Den			39
1978	4-1	A	F	Nomad	1978	21	
1978	4-4	A	M	Den/nomad			39
1978	39	J	M				27
1978	4-2	J	M	Disperser	1978	7	
1978	44	J	M	Disperser	1979	10	
1978	4-6	J	M	Disperser	1979	10	
1978	4-3	J	M	Den/nomad	1979	21	
1978	47	J	M				27
1978	42	J	F	Disperser	1979	21	
1978	46	J	M	Disperser	1979	10	
1978	40	J	F				27
1978	45	J	F	Disperser	1979	21	
1978	49	J	M				27
1978	43	J	M	Disperser	1979	18	
1978	41	J	M	Disperser	1979	16	
1978	50	J	F				27
1979	4-11	A	F	Den			27
1979	4-7	A	M	Den			27
1979	4-8	A	M	Den			27
1979	3-11	A	M	Den			27

[1/] Minimum months

Density

Seasonal density is an important characteristic of coyote populations. The extreme difficulty of accurately censusing this species has kept many investigators from using this important parameter. Based on our best estimate of the coyote population in the breaks habitat from 1977 to 1979 (Table 8), the fall coyote density averaged 1.0/mi^2 (range of .9 to 1.1) and spring density averaged .4/mi^2 (range of .35 to .43). Density in prairie habitat was lower and more variable but was not studied intensively.

Knowlton (1972) reported a (fall?) coyote density of 2.3/mi^2 in a 30 mi^2 area with six dens, a density range in Texas of 0 to 6/mi^2, and an average density (season?) of .5 to 1.0/mi^2 over a "large portion of their range." Knowlton's observed density of 2.3 was in an area which averaged 5 mi^2/den area, comparable to the Missouri Breaks; however, he estimated more nonbreeders and a higher average litter size than we observed.

Camenzind (1978) estimated an average breeding density of 1.4/mi^2 and an average postwhelping density of 3.6/mi^2 for the National Elk Refuge in western Wyoming. His average litter size was slightly higher (4.4) than was observed in the Missouri Breaks (3.6); however, the average size of den areas (2.5 mi^2) was much smaller on the National Elk Refuge (calculated from the number of litters divided into the area of the refuge studied).

One variable that is very difficult to estimate is the number of nonbreeding coyotes, both nomads and supernumary den adults. Of 23 spring adult coyotes (22 spring trapped adults, 1 fall trapped juvenile) telemetered during one or more spring denning seasons, 65 percent (15) were associated with dens and 48 percent (11) were apparent breeders. The limitations of small yearly samples plus a possible sampling bias (nonbreeders may be more easily trapped than are breeders) would suggest that these percentages probably overestimate the non-breeding cohort in the population. Still it must be implied that the actual density could be somewhat higher than our results indicate due to the problem of underestimating nonbreeders. The siren survey may detect some of these but nonbreeding females may be the least vocal group (Wenger and Cringan 1978).

Knowlton (1972) estimated the average number of nonbreeders equalled the number of breeders but had a very wide range between years and areas. Camenzind's (1978) data indicated a range of nonbreeders from 11 (1972) to 60 (1975) percent of the spring population. Changing the size of his study area during 1974-75 creates some scientific procedure problems with comparisons of his data for 1971-73.

Postwhelping density can be very misleading. Juvenile coyotes make up approximately one-half or more of the total number, yet they are not equal to adults in predatory ability or effect. Fall dispersal of juveniles rapidly reduces the temporarily high early fall density.

Knowlton (1972) indicated that density varied over large areas. The data for the Missouri Breaks indicate that density varies greatly over small areas, such as between the breaks habitat and the prairie habitat, apparently reflecting the continuum in habitat quality.

Coyote Predation on Deer

Studies of the effects of predators on wildlife are relatively recent. Historically predation on domestic livestock has dictated attitudes, policies

and politics regarding predator control. Many people supposed that predation on wild animals was homologous with predation on domestic animals. The apparent corollary, and widely exploited by proponents of coyote control, was that predator control benefitted wild animals as much as it did domestic animals.

Deer, elk and antelope (as well as other wildlife species), evolved a predator defense behavior to cope with the ever-present threat from a wide range of predators. Proficient use of cover (vegetation and terrain), swiftness and endurance in flight, keen senses and alterness, and aggressive behavior toward individual predators have enabled ungulates to cope with predators where some domestic animals cannot because they no longer make use of these defense behaviors. Changes in cover as well as changes in animal distribution have influenced the degree of success that each species' behavior can provide.

Leopold (1933) discussed relationships of prey-predator ratios and their relation to density. He also discussed "buffers to divert the attention of predators and satisfy their food requirements." That principle does not cover some of the deer-coyote relationships in the Missouri Breaks. The abundance of voles during 1978-79 apparently overrode prey-predator ratio and density considerations relative to deer-coyote relationships. The effect of high vole populations was to almost eliminate predation by coyotes on deer. The role of cottontail rabbits, as prey successors to voles, has yet to be determined.

Seasonlong grazing by cattle may seriously reduce voles by reducing residual cover, especially in draws and swales (Hamlin pers. comm.). Thus, livestock grazing of this kind may be causing increased predation on deer, particularly fawns.

Coyotes apparently prey most on deer when more preferred prey is scarce. Thus, deer become "buffer" species (not the traditional definition of buffer species) for coyotes. This situation allows some coyotes to survive at a higher rate than if they depended solely on the major prey items; however, the population of coyotes declines, indicating that many are going short of food under these conditions. Reduced food could eliminate many coyotes and reduce reproduction for survivors, which we apparently witnessed during 1976-77. If coyote foods continue to follow abundance cycles of the providing species (voles, mice, rabbits, deer), deer appear to be less important to coyotes than are small mammals. It is not known whether changes in coyote social organization affect predation on deer. Pups may return to den areas, where more successful adult hunters may help feed them, causing pups to remain longer near the den area. The highest number of supernumary den adults was observed during the period of highest coyote predation on deer.

The deer population decline, attributed to the severe 1971-72 winter, reduced deer density to approximately one-half their peak numbers (Hamlin 1979). The status of the coyote population and their predation on deer before, during and after a peak still has not been studied. The high predation observed on adult deer during winter 1975-76 (Knowles 1976) and fawns during summer 1976 and 1977 (Dood 1978) occurred during the low of the deer population cycle. Heavy, thick ground ice, which occurred during the otherwise relatively mild winter of 1975-76 (Hamlin 1979), accompanied the highest observed winter predation on deer.

Population dynamics of both deer and coyotes must be followed for several more years in addition to monitoring coyote predation on deer, before objective evaluation of the problem can be made and recommendations for management can be formulated.

Without additional data on deer losses and coyote numbers during the deer decline, it would be risky to draw conclusions on how much coyotes contributed to the rate, depth, and duration of the deer population decline. The effect of coyote predation on deer is incomplete at this time. The data obtained to date do not substantiate Calvert's (1975) claim of "800-1400 deer killed on the ice" each year by coyotes on the CMR.

Siren Survey Technique Refinements

Although the siren technique of surveying coyotes by elicited responses has been criticized as being too variable and thus unreliable (Lemos 1978), the data from this study suggests that the technique can provide a very useful census of coyotes, probably better than any other presently used method. It is also obvious that some improvements could be made in the technique by employing some of the presently available electronic sound equipment. Listening devices, recorders and recorded calls, volume sensors, and frequency analyzers could increase the accuracy of survey, particularly the number, location and possibly age of coyotes howling in multiple calls.

The siren survey was made with the following assumptions:

1. The coyote's daily summer routine appears to be: an evening hunting and feeding period, rest and possibly ceremonial howling, extensive nighttime travel for territorial scent marking and intruder investigation, morning hunting and feeding and possibly ceremonial howling, and rest during most of the day. The winter behavior routine may differ but is inconsequential unless a survey procedure is proposed.

2. Coyotes howl in response to the siren as a) a territorial defense behavior normally directed at an intruder or a member of an adjoining social group and b) to communicate with other den members. Nomad coyotes may howl for other reasons.

3. Coyotes may also respond to the siren by approaching it (without howling), a behavior that may be more prevalent during high illumination by a full moon.

4. Coyotes respond to the siren as well as to other coyotes. Howling coyotes may elicit more responses than were caused by the siren.

5. Most of the coyotes are confined to traditional den areas which reduces the likelihood of getting duplicate answers from coyotes in one den area. The highest number of individual howls from each station represents the coyotes in the den areas which are adjacent to the listening station.

6. Coyotes may answer the siren or howl for other reasons before the observer enters the listening area around a station and be missed on that survey. Repetition of the survey may reduce the number of coyotes missed for this reason.

The coverage and/or accuracy obtained by the siren survey was determined on the basis of the highest number of coyotes accounted for (Table 8). Several den areas (J, L, N, O, Q) were consistently not detected by howling, presumably due to the station being too far from the bulk of the den area. When allowance was made for these nonresponding den areas, the siren survey found 67 to 81 percent of the occupied den areas as indicated by multiple responses. The highest coverage was obtained during 1979, the last year, hopefully indicating that technique improvements were being made.

Responses identified as to den area were compared to high station counts (Table 11). The two analyses compared favorably, with calls assigned to den areas producing a slightly higher total. This may be caused by adjacent den area coyotes howling in response to each other. High station counts averaged over 90 percent of the high den area counts.

Table 11. Comparison of coyote answers from high station counts and high den area counts for the South Missouri Breaks, 1976-79.

Route	Method	Year				
		1976	1977	1978	1979	Ave.
Wilder-Sand Cr.	High Den Area	58	55	35	66	54
	High Station	56	51	35	56	49
	Percent	97	93	100	83	92
Musselshell-Skyline	High Den Area	53	35	45	37	42
	High Station	50	33	40	28	38
	Percent	94	94	89	76	88
Combined	High Den Area	111	90	80	103	96
	High Station	106	84	75	83	87
	Percent	95	93	94	81	91

Comparing the high station count density (Table 4) to the density of the highest count (Table 8), omitting 1976 when no den area estimate was made, indicated an average of 55 percent (range of 43-64) of the coyotes were surveyed by the siren from 1977 to 1979. Since the technique is still developmental, that average may be too low considering present refinements.

Comparing siren responses with den area estimates in 1979 (Table 8) indicates the coyotes heard on the siren survey closely approximated the number we were able to confirm by sightings.

The presently recommended procedure guidelines for coyote siren surveys are:

1. Start during early July and try to finish before September, when wind may be more troublesome.

2. Select nights for surveying that are calm.

3. Survey during the hours 1100 PM to 400 AM.

4. Use a heavy duty siren (we used a Federal, Model 28), sound the siren to one side of the route for 20 seconds, listen at least 2 minutes, sound the siren to the other side of the route for 20 seconds, and listen for 2 minutes.

5. Record coyote howls as to: number, direction and distance (estimate the number of coyotes calling in multiple calls).

6. Repeat the survey twice on the same route, using listening stations that are near the same location on each survey. Station sites should be selected on knolls, not in depressions.

7. Sample the same habitat type or habitat complexes with similar densities of coyotes.

8. Analyze responses on the basis of the highest number at each station and the highest number in each probable den area.

9. It is helpful to have 2 people making the survey.

10. Do not rely on this technique in areas where coyotes may be habituated to sirens or where high levels of background noise may interfere with hearing.

RECOMMENDATIONS

The problem of coyote predation on deer probably will continue in the Missouri Breaks as well as in other areas of Montana. Since the Montana Department of Fish, Wildlife and Parks has never been actively involved in coyote management, the department has not researched coyote problems. Without research results to direct conclusions on predation, the money ($80,000) supplied by the Fish and Game Commission for predator control cannot be spent where wildlife could most benefit. Thus, the department cannot fulfill its responsibility for supervising all wildlife and managing game populations without research into coyote predation on wildlife.

It is recommended that:

1. Research should continue in the Missouri Breaks through the next period of high deer mortality from coyote predation or through the next period of low deer population.

2. Siren surveys should be continued on both sides of the study area to monitor the coyote population and to improve this or another survey technique.

3. A contingency plan to control coyotes should be prepared, including all other actions and reports necessary to carry out the coyote control plan.

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STATE OF MONTANA

DEPARTMENT OF FISH, WILDLIFE AND PARKS

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... 15 1981
WILDLIFE DIV.

Office Memorandum

DATE: 7/14/81

TO : Gene Allen

FROM : John Weigand JW

SUBJECT: Coyote Biology and Ecology in Montana

The following information has been gleaned from Pyrah's (1980) and Schladweiler's (1980) reports and Phil's recent MO article. Some are new findings, while others are standard study data, but from recent Montana conditions. A total of 37 marked coyotes (26 radioed plus 11 neck-collared) provided much of the information, 1977-1980.

Social Organization

Four classes of coyotes have been identified: den, supernumary, nomad and dispersing. Den adults are generally the breeders, while supernumary are adults (probably yearlings from last year's litter) which are nonbreeders. Nomad adults are those which have been unsuccessful in obtaining a mate and/or establishing a den; they occur as single animals. Dispersing coyotes are mostly juveniles, after weaning in the fall; they can also be adults at that time. An individual coyote can be in each of the four categories during its lifetime.

Home Ranges (Missouri River Breaks)

Social Category		Males	Females
Den Breeders:	No. Radioed	8	3 lactating
	No. Relocations	33	33
	No. Days Tracked	336	331
	Home Range (mi^2)	3.2	3.1
Nomads:	No. Radioed	3	2
	No. Relocations	34	26
	No. Days Tracked	370	324
	Home Range (mi^2)	56.4	29.1
Dispersers:	No. Tracked	8	
	Distances moved	8-95* (all 1-way movements)	

* 1 moved 8 miles, 4 moved 15-18 mi., 2 moved 50 mi, and 1 moved 95 mi.

Density (Missouri River Breaks)

1. 1977-1979 averaged approximately 1 coyote per square mile.
2. Den areas included 5-6 square miles each.
3. Population regulation is by dispersal, mostly by juveniles away from dens; dispersal is functionally the same as death!

Mortality

1. Mo. River Breaks = 43% in 1977-1978 and 44% in 1978-1979.
2. Statewide = 46%.
3. Only 31% of all juveniles need survive to replace deaths by adults in any given year.

Predation by Coyotes

Predation on 66 radioed mule deer fawns during 1976-1979 by coyotes was 73% of known fawn mortalities, but only 17% of all monitored fawns. The difference in definitions is accounted for in that not each fawn in a set of twins was radioed. Mortality of fawns due to coyotes was highest in 1976 (100% and 36% by the above definition) and lowest in 1978 (50% and 7%); these levels of predation correspond to low vole populations in 1976 and higher vole numbers in 1978.

The following 3 paragraphs are quoted from Pyrah (1980:30) and appear especially pertinent to your needs:

"Deer, elk and antelope (as well as other wildlife species), evolved a predator defense behavior to cope with the ever-present threat from a wide range of predators. Proficient use of cover (vegetation and terrain), swiftness and endurance in flight, keen senses and alertness (Stt2), and aggressive behavior toward individual predators have enabled ungulates to cope with predators where some domestic animals cannot because they no longer make use of these defense behaviors. Changes in cover as well as changes in animal distribution have influenced the degree of success that each species' behavior can provide.

"Leopold (1933) discussed relationships of prey-predator ratios and their relation to density. He also discussed 'buffers to divert the attention of predators and satisfy their food requirements.' That principle does not cover some of the deer-coyote relationships in the Missouri Breaks. The abundance of voles during 1978-79 apparently overrode prey-predator ratio and density considerations relative to deer-coyote relationships. The effect of high vole populations was to almost eliminate predation by coyotes on deer. The role of cottontail rabbits, as prey successors to voles, has yet to be determined.

"Seasonlong grazing by cattle may seriously reduce voles by reducing residual cover, especially in draws and swales (Hamlin pers. comm.). Thus, livestock grazing of this kind may be causing increased predation on deer, particularly fawns."

The definition of "buffer species" becomes confusing, e.g.,:

(1) Voles are buffers to deer when coyotes are hunting normally, and
(2) deer become buffers to voles when vole populations are down.

Behavior

Coyotes depend on voles as a primary source of food. When vole populations are high, coyotes eat well, coyote reproduction is high, and one would notice lots of coyotes dispersing from secure habitats; also, numbers of supernumary or non-breeding adults at dens are lower in frequency. When voles are scarce, coyote

reproduction is down, numbers of supernumary adults at dens increases (the previous year's pups "stay home"), and the ability by adult groups to successfully prey on deer increases because more adults are hunting together, and predation on deer increases; more juveniles may again decide to "stay near home" and the number of dispersers decreases. Highest numbers of supernumaries were noted in low vole-high deer depredation years. We are still trying to reveal the role of rabbits in this continuum.

Control Methods

Aerial gunning of coyotes is effective in reducing numbers of dispersing and nomad coyotes, mostly because they are away from secure habitats. It would not be especially consequential to coyotes in secure habitats because they remain there, having no reason to move.

Placing of poisoned baits (e.g., 1080, cyanide guns) at densities of less than 6 stations per township will also probably be effective on dispersers and nomads. Stations placed at greater densities could get some of the breeder coyotes, depending on the class of habitat for coyotes.

In an "average year", 60% or more of a total coyote population would have to be killed/removed to effect the population; i.e., 69% of all juveniles can be removed with no adverse effect on the population. Approximately 75% of a population has to be removed every year for continued control.

In summary, I believe this includes most of the "new" information available, i.e., it involves mainly coyote behavior and social organization. Compound 1080 would be a useful tool, used as individual baits placed in carefully selected areas, to reduce coyote predation on low deer populations in "low rodent" years. However, our data cannot condone the previous widespread or broadscale use of such baits at this time. I would think that sheep-raisers would also want to use it in a similar manner. Also, see copy of my earlier memo on this (2/3/81 - attached).

sf
Att.

1080 Single Lethal Dose Baits - British Columbia Information

In conversations with animal damage control specialists in British Columbia, we have learned that they are using small baits containing 1080 to control coyotes and wolves. Communications with this group are continuing but, due to the mail strike in Canada, exchanges of written information are impossible.

Basically, the coyote control program involves the use of baits composed of tallow, bone marrow, and paraffin. The mixture is heated, poured into a cylindrical mold, cooled and cut into small cylinders. A depression is melted into the cooled cylinders of bait and powdered, technical 1080 placed in the depression which is then sealed with an amount of the melted bait. The ratio of 1080 in the bait is 3 mg 1080 per 55 g. of bait.

Coyote baits are placed in areas where coyote depredation has occurred and are buried 2-3 inches into the soil. A fish oil base attractant is used to draw coyotes to the bait. A drop of attractant is placed on the ground above the buried bait and on a nearby tree or object. This attractant has reportedly been successful in attracting coyotes from as far away as 300 yards. The technique of burying bait has been developed during the past 30 years in order to protect some non-target wildlife from the hazard of 1080 poisoning.

In certain instances where coyote predation had occurred on sheep, 1080 has been placed in sheep meat on fleece. This method has been successful in controlling coyotes that had become accustomed to eating sheep meat.

For control of depredating wolves, 1080 is placed in squares of beaver meat. The ratio of 1080 in the baits is unknown at this time but the method of placement is the same as for coyote baits. Beaver castor is used as a wolf attractant.

Coyote and wolf baits are prepared in some number and frozen for later use.

The use of 1080 in large pieces of animal meat (bait stations) has been limited in British Columbia because of observed non-target wildlife mortalities in conjunction with bait station use. However, for control of feral dogs and for controlling coyotes in the "lowlands", a modified bait station technique is used. 16 mg of 1080 is placed in a 1 kilogram piece of meat that contains a large bone for anchoring the poisoned meat in place.

Restrictions associated with the use of 1080 are quite extensive. We have not reviewed the regulations but are aware of the following:

1. No more than a total of 5 grams of 1080 can be applied in British Columbia during one year for coyote and wolf control combined.
2. Non-target mortalities are closely monitored and investigated.
3. Placed baits are checked within 10 days and must be picked up within 14 days.
4. All 1080 bait handlers are trained, tested, and licensed.
5. To place baits within 1 kilometer of a habitation, written permission from the resident must be obtained.
6. To protect wildlife from 1080 poisoning, certain areas have been restricted to baiting only during winter months.

As a point of interest, this group has discontinued the use of M-44's because of the hazards to applicators, failure of the mechanism due to various intrinsic and environmental reasons, hazards to non-targets (primarily cattle), and the intensive training that was necessary for applicators.

Communications are continuing with this active predator control group. When the postal strike is resolved, we can review their regulations and methods more completely.